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GENERAL

MECHANICS OF SOLIDS

MECHANICS OF FLUIDS

HEAT

MISCELLANEOUS

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APPLIED MECHANICS REVIEWS

VOL. 5, NO. 9 **MARTIN GOLAND** *Editor* SEPTEMBER 1952

Communications

Correction to **Rev. 827** (**March 1952**), **Kampé de Fériet, J., and Betchov, R.**:

The reference should read *Proc. kon. Ned. Akad. Wet.* (*B*) **54**, 4, 389–398, Sept./Oct. 1951.

Theoretical and Experimental Methods

(See also Revs. 2560, 2659, 2664, 2668)

2536. Scarborough, J. B., Numerical mathematical analysis, Baltimore, The Johns Hopkins Press, 1950, xviii + 511 pp. $6.

Chapters deal with accuracy and errors (I); interpolation and quadrature (II–VIII); algebraic and transcendental equations (IX–X); ordinary (XI) and partial (XII) differential equations; integral equations (XIII); the normal law, precision of measurements, and least squares (XIV–XVI); harmonic analysis (XVII).

Included with the first topic are rules for counting significant figures in products, quotients, roots, elementary transcendental functions; remainder formulas for Taylor expansions; a brief consideration of linear equations.

For interpolation, the Newtonian, Gaussian, and Lagrangian formulas are given, with remainders and a technique for deriving remainder formulas; three methods of inverse interpolation; two methods for functions of two variables; and a sine formula for periodic functions. Formulas for differentiation are given, but not error formulas. Formulas for quadrature include Gauss', a modification due to Lobatto which utilizes ordinates at the ends, Euler's, and Chebíshev's, as well as a chapter on remainders. Notable omissions are divided differences, Aitken's method, and Chebíshev polynomials.

For a single equation, the methods are false position, Newton's iteration (of which these are special cases), and Graeffe's. The second and third of these are extended to systems, and a convergence criterion derived. Notable omission is Bernoulli's method.

On ordinary differential equations a discussion of Euler's and Picard's methods is followed by general consideration of the application of polynomial approximations, with special attention to Milne's method and to the Runge-Kutta method. Nearly 20 pages are devoted to exterior ballistics.

Iteration, relaxation, and Rayleigh-Ritz methods are given for partial differential equations. A brief chapter on integral equations applies standard quadrature formulas, and considers even nonlinear equations.

Some little space is devoted to a derivation and discussion of the normal law of errors, and to measures of precision. The least squares method is applied to linearized nonlinear functions, in addition to the ordinary linear case.

The chapter on harmonic analysis includes the cases of 12 and of 24 given ordinates.

The book presupposes only calculus; the treatment is illustrative rather than demonstrative, by means of examples worked in detail, and accompanied by selected problems and answers. Passing references are made to the use of sequenced computing machines, but this motivates the development only negligibly. Most unsatisfactory is the perfunctory treatment of linear algebraic systems, though these occur repeatedly (e.g., in the solution of integral and of partial differential equations). It is stated that Newton's method, and the iteration method generally, do not apply to complex roots, though the application is formally identical with that for real roots; and Graeffe's method is discussed for algebraic equations only, though the extension to transcendental equations is almost immediate. Omission of convergence criteria for the methods of iteration and relaxation leaves the reader in the dark as to where they can be used.

In spite of these and more minor defects (including numerous misprints), the book is a valuable one, with a wealth of illustrative material, and should be easy to follow even by those whose background is minimal.

A. S. Householder, USA

2537. Brooks, F. E., Jr., and Smith, H. W., A computer for correlation functions, *Rev. sci. Instrum.* **23**, 3, 121–126, Mar. 1952.

Correlation functions of data, such as fading radio signals or temperature and humidity fluctuations of the atmosphere offer a powerful tool for analysis. By conventional methods, computation of these functions is long and tedious. This paper describes a computer which was constructed for this purpose. The data to be studied are transcribed onto magnetic tapes which are then run through a computer which computes the auto- or cross-correlation functions and plots the resulting function through a recording meter. An example of the application of this computer to the study of the turbulence of the atmosphere is shown.

From authors' summary

2538. Emery, E. T. G., The sampling of small coal, *Engineering* **172**, 4472, 452–454, Oct. 1951.

2539. Kempthorne, O., The design and analysis of experiments, New York, John Wiley & Sons; London, Chapman & Hall, 1952, xix + 631 pp. $8.50.

During recent decades the terms "experimental design" and "experimental analysis" have been appropriated by the biostatisticians to designate a very special branch of activity central to experimental work in the empirical sciences. A principal objective is "randomization" of the influences of extraneous variables in complex experimental configurations. A simple illustration from fluid mechanics is the use of a nonmonotonic relation between position and time sequences for the probe during measurement of a velocity profile. Thus, any unnoticed monotonic drift in ambient conditions will show up as a scatter in the data instead of causing a systematic distortion, possibly not detected as an error. In experimental applied mechanics, where we have moderate control over conditions plus the possibility of a complementary analytical attack, such considerations are incidental techniques; in biology—in a considerably more elegant and complex form—they are the core of the experimental design.

This book is a complete and up-to-date account of the mathematical derivations of the various procedures for randomization by an author active in the development of the field. It includes

expositions on such topics as "randomized blocks," "Latin squares," "factorial experiments," "confounding," "incomplete block design," "lattice designs," etc.

The treatment is at graduate level, and strongly presupposes a real familiarity with the elementary theory of statistics, including the jargon, and with the use of matrixes. Even the supposedly introductory review material in the first few chapters requires such knowledge.

Both timeliness and wealth of detail make this book a genuine contribution, especially to the experimental sciences of biology and psychology, and also to such fields as economics and industrial engineering, where "experimental" conditions are almost always complex.

Possibly the reviewer's only serious disappointment in the book is its abbreviated (2 $^1/_2$ pages) mention of the question of measures of information, especially in a text aimed more at fundamentals than are some of its predecessors. It is conceivable that within the next few decades the whole theory of quantitative experiment will be reset onto the foundation of "information theory."

Stanley Corrsin, USA

2540. Meyersberg, G., Statistical considerations of the strength of cast iron (in German), *Arch. Eisenhüttenw.* **22**, 11/12, 377–385, Nov./Dec. 1951.

Statistical investigation of the influence of size on the static strength of materials. The meaning of the constants in Weibull's formula for the failure probability at stress x, $1 - \exp V[(x - x_u)/x_0]^m$, is discussed. The formula is applied to data from bending and torsion experiments on cast-iron test specimens.

Nils G. Blomqvist, Sweden

2541. Cook, G., Rankine and the theory of earth pressure, *Géotechnique Lond.* **2**, 4, 271–279, Dec. 1951.

Biographical sketch of J. M. Rankine (1820–1872) and critical discussion of Rankine's contributions to the theory of earth pressure.

O. Hoffman, USA

2542. Crookshanks, R. J., Supplementary tables for special functions used in the calculation of airloads on oscillating wings (special functions of NACA TN 1195), *Douglas Aircr. Co. Rep.* SM-14200, 12 pp., Nov. 1951.

Author tabulates the Theodorsen function together with other special combinations of Bessel functions, and a complicated integral with three parameters.

A. van Wijngaarden, Holland

2543. Pipes, L. A., The reversion method for solving nonlinear differential equations, *J. appl. Phys.* **23**, 2, 202–207, Feb. 1952.

Practical procedure (without proof of convergence) for solution of equations of type

$$a_1 y + a_2 y^2 + \ldots = k\phi(t)$$

where the a_i are operators which are functions of $D = d/dt$, k is a parameter, and ϕ a given function. Solution is given in the form of a series

$$y = A_1 k + A_2 k^2 + \ldots .$$

A_n, $n > 1$, is determined by linear differential equation involving preceding A_i, A_1 is obtained directly by equation of same type from $\phi(t)$. Applications to examples form main part of investigation.

A. van Heemert, Holland

2544. Duncan, W. J., Note on a generalization of Rayleigh's principle, *Quart. J. Mech. appl. Math.* **5**, part 1, 93–96, Mar. 1952.

Any root λ of the characteristic equation of a set of n linear ordinary differential equations with constant coefficients and of order m is also a root of an equation of degree m whose coefficients are quadratic forms in the modal coordinates corresponding to λ. It is shown that, when the matrixes of the coefficients of each order in the differential equations are symmetric, the root λ of the equation of mth degree is stationary for small deviations of the modal coordinates from their true ratios for the mode considered.

From author's summary

2545. Wilson, E. M., Solutions of the equation $(y'')^2 = yy'$ and two other equations, Admiralty Res. Lab., Teddington, Middlesex, 10 pp., Nov. 1951.

The first part of this report is concerned with a solution of $y'' = -(yy')^{1/2}$ such that $y(0) = 0$, $y'(0) = 1$. The solution depends on the inversion of the integral $x = {}_0\int (1 - t^{3/2})^{-2/3}$ dt, where x is the independent variable. A generalization of this integral has been studied by R. Grammel [AMR **4**, Rev. 1886]. When x approaches $4\pi 3^{1/2}/9$, y approaches unity while y' and y'' approach zero. Starting at this point the function tabulated is the solution of $y'' = +(yy')^{1/2}$ which admits of an integral representation similar to the previous one. Series solutions are also given. A photostat table is available giving y to 6d for $x = 0(0.002)6.0$ and $\log_{10} y$ to 6d for $x = 6.0(0.01)7.5$. The report tabulates y to 6d for $x = 0(0.05)0.5(0.1)6.0$. Author believes maximum error is less than 0.7 unit in the last figure. Second differences, mostly modified, are also tabulated. To facilitate interpolation near the origin, $y + 4x^{3/2}/15$ is tabulated to 6d for $x = 0(0.05)0.25$.

In the second part, values of the integral $F(\beta, \rho) = (2e^{-\rho^2}/\beta^2\pi^{1/2})_0\int^\beta I_0(2\rho\eta)e^{-\eta^2}\,d\eta$ are tabulated to 4d for $\beta = 0(0.24)4.0$, $\rho = 0(0.25)5.0$. I_0 is the modified Bessel function. Computation was by quadrature and author claims entries are correct to within one unit of the last figure. Table has been subtabulated for $\beta = 0(0.05)2.5$, $\rho = 0(0.05)5.0$, and is available in photostat form. This function has found application in ballistics and heat and mass transfer. A more extensive tabulation of a function simply related to the above has been made by others. [See S. R. Brinkley, Jr., and R. F. Brinkley, "Table of the probability of hitting a circular target," and S. R. Brinkley, Jr., H. E. Edwards, and R. W. Smith, Jr., "Table of the temperature distribution function for heat exchange between a fluid and porous solid," U. S. Bureau of Mines, Pittsburgh, Pa. Copy is available on loan on application to the authors. Articles are reviewed in *MTAC* **2**, p. 221, and **6**, p. 40, respectively.]

Part 3 tabulates to 3d that zero of $u \sin x - \cos x + e^{-ux} = 0$ which lies between π and 2π for $u = 0.1(0.01)0.3(0.02)2.0$, and $u^{1/2} = 0(0.02)0.5$. Author states last figure should be correct to within 0.7 of a unit. Linear interpolation yields full accuracy and first differences are provided.

Y. Luke, USA

2546. Bachmann, K.-H., On the approximate solution of algebraic equations (in German), *ZAMM* **31**, 11/12, 390–392, Nov./Dec. 1951.

A semigraphical method of approximate analytical continuation is given for a function of a complex variable based on representing the function in each neighborhood by a polynomial of second degree. This is applied to the problem of locating complex roots of polynomials. An example is worked.

Stephen H. Crandall, USA

2547. Olver, F. W. J., The evaluation of zeros of high-degree polynomials, *Phil. Trans. roy. Soc. Lond.* (*A*) **244**, 885, 385–415, Apr. 1952.

This paper is an attempt to make universal the approach to solve high-degree polynomials, i.e., polynomials of degree greater

than about 6. It discusses the various difficulties that occur in practice and considers in great detail the application of classical methods to arrive at the final solution. The treatment is largely expository, but is novel in that its aim is directed toward attaining technical perfection in the application of known standard methods. Paper is a handy guide for the computer.

In part A, direct methods of solution are studied. Examples are inverse interpolation, the Aitken-Bernoulli process, and the root-squaring process of Graeffe including its extensions. Inverse interpolation is useful for evaluating real zeros, but where several complex zeros are present, other techniques are necessary and it is preferable to use methods which include the determination of real zeros as a special case. For the evaluation of complex zeros, author compares the Bernoulli process as modified by Aitken with that of Graeffe and concludes that the latter is far more powerful and useful. Theoretical details and numerical examples are given to support his thesis. Major portion of paper deals with the root-squaring process, and author gives answers to the usual objectionable features of the method, namely, that it is not self-checking and that end figure errors accumulate rapidly.

Part B considers indirect methods. These include the numerous procedures involving successive approximations (iterative methods). Author believes these methods are most useful when a good approximation is already known, for convergence is often slow and not always guaranteed. Thus, iterative schemes are regarded as supplementary but not alternative to direct methods. In this approach, author differs from Lin and others [AMR 5, Rev. 10]. (See also A. C. Aitken, *Proc. roy. Soc. Edinburgh* 63, pp. 174–179, 1951.) Though the methods of Lin and Aitken are sometimes slowly convergent, the latter has communicated to the reviewer techniques to remove the linear error and so make the convergence quadratic. This is to be the subject of a forthcoming paper by Aitken and should add to the usefulness of the above iterative methods.

Finally, part C is a discussion of miscellaneous topics including rounding errors in coefficients and complex coefficients.

Y. Luke, USA

2548. **Godwin, H. J., A method for the evaluation of** $\int^{\infty} x^m[(2/\pi)^{1/2}\ {}_x\!\int^{\infty}\mathbf{exp}\ (-1/2\ t^2)\ dt]^n dx$, *Quart. J. Mech. appl. Math.* **5,** part 1, 109–115, Mar. 1952.

The integral ${}_0\!\int^{\infty} x^m[(2/\pi)^{1/2}\ {}_x\!\int^{\infty} \exp\ (-1/2\ t^2)\ dt]^n\ dx$ is evaluated by expressing it as a series of reciprocals of factorial functions of n; the accuracy of this method increases with n. It is shown how the method may be modified to improve the accuracy for small values of n. From author's summary

2549. **Pankhurst, R. C., N.P.L. aerofoil catalogue and bibliography,** *Aero. Res. Counc. Lond. curr. Pap.* 81, 20 pp., July 1951, published 1952.

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 2555, 2602)

2550. **Hertig, R. R., Contribution to the study of plane motion** (in Spanish), *Cienc. y Técn.* **118,** 596, 72–76, Feb. 1952.

Paper considers plane motion of centrode of curvature $1/\rho_2$ over fixed centrode of curvature $1/\rho_1$. Given pole linear velocity v, acceleration v^1, relative angular velocity ω, acceleration ω^1, rate of change of acceleration σ, unit vectors tangential and normal to pole path $\mathbf{l}$, $\mathbf{c}$, respectively, author derives diameter of circle of inflection $d_i = 1/\{(1/\rho_1) - (1/\rho_2)\}$; acceleration of pole $a_\mathbf{c} = v^1\mathbf{l} + (1/\rho_1)\ v^2\mathbf{c}$; acceleration of inflection pole I: $\mathbf{a}_i = \omega^1 d_i\mathbf{l}$; rate of change of acceleration of inflection pole I: $\mathbf{s} = \{(1/\omega)\ \sigma\ v + (1/\rho_1)\ \omega v^2\}\mathbf{l}$. Absence of normal component from last two expressions shows that I is a point of undulation.

Ewen M'Ewen, England

2551. **Devaux, L., The bifilar pendulum, damper of torsional vibrations** (in French), *Rev. univ. Min.* (9) **7,** 8, 237–250, Aug. 1951.

Author studies the problem of elimination of torsional vibrations in a shaft revolving with variable speed. Three solutions are known: The Lanchester damper, the Frahm pendulum, and the bifilar pendulum of Sarazin. Author prefers the last arrangement, because it meets the most requirements of a shaft subjected to a torque which includes several harmonics, the influences of which are to be eliminated. After a short theoretical study of the oscillating system with one degree of freedom, an oscillating system of two degrees of freedom is treated which is composed of the main oscillator, the amplitude of which is to be limited, and another oscillator which can oscillate freely. The latter, named the "dynamical damper" of oscillation, possesses either a constant natural frequency or a natural frequency proportional to the disturbing frequency. A monofilar pendulum is not suitable for such a dynamical damper because it can eliminate only one harmonic of the torque. Therefore, author proposes a bifilar pendulum in which all points describe arcs of the same radius. He offers a model suitable for practical use.

W. Kochanowsky, Germany

©2552. **Bloch, S. Sch., Approximate mechanism design [Angenäherte Synthese von Mechanismen],** Berlin, Verlag Technik, 1951, 176 pp.

See AMR **4,** Rev. 3473 (Blokh).

©2553. **Dobrovol'skiĭ, V. V., Theory of mechanisms [Teoriya mekhanizmov],** Moscow, Gosud. Nauch.-Tekh. Izdat. Mashinostroit. Lit., 1951, 465 pp.

This is a first, but remarkably comprehensive course with the following distinctive features. Traditional geometry of motion is treated only in the context, and limited to the bare essentials (e.g., no mention of the Euler-Savary theorem could be found). The dynamics (with friction accounted for) and kinetostatics of each group of mechanisms are discussed jointly with their kinematics. The author's classification of mechanisms (widely favored in USSR) is presented in full detail (55 pp.) and used to organize the material. Some recent results (especially the author's, e.g., formulas for transmission efficiency) are included, but no topic is treated on the design specialist's level. Space mechanisms are given little attention in spite of the author's work in this field. The basic idea of the classification is: If, after the kinematic pairs are disconnected, the rigid members have m degrees of freedom, the mechanism is of class $m - 1$, and the Gruebler formula becomes $mn - \Sigma_k(m - k)p_k$, $k = 1, \ldots, m - 1$, if n is the number of links and there are no passive constraints. Two-link mechanisms are assigned to class zero.

A. W. Wundheiler, USA

Gyroscopics, Governors, Servos

©2554. **Anonymous, Aircraft gyroscopic flight instruments, 5th ed.,** London, Sperry Gyroscope Co., Ltd., 1952, 82 pp.

Book has been written primarily to acquaint pertinent non-engineering personnel, such as ground and air crews who may come in contact with this company's gyroscopic equipment, with the general operating principles and constructional details of

these instruments. Instruments treated are turn and slip indicators, directional gyro, gyro horizon, gyrocompass, zero reader flight director, and some versions of an automatic pilot.

Book is well written and material concisely presented. Although an engineer interested in these instruments would not find all the discussion and detail that he might desire, this book should, nevertheless, be useful to him as a handy reference.

Leonard Becker, USA

2555. Platrier, C., Contribution to the study of the action of the rotation of the earth on the local motion of a solid (in French), *Ann. Ponts Chauss.* **121**, 6, 655–664, Nov.–Dec. 1951.

Article is dedicated to the centenary of Foucault's experiment (1852). In the theory of the pendulum and weighted symmetrical gyroscope rotating about a fixed point, the influence of the horizontal component ω_2 of the earth's angular velocity is neglected. Assuming ω^2 small in comparison with ω, author gives the equations of motion of the gyroscope, in which one sees the influence of ω_2. Two cases are considered: (1) When the axis of gyroscope remains in the neighborhood of the meridian plane in the fixed point; (2) in arbitrary vertical plane. In the first case, the problem can be solved by three quadratures; in the second, by four. The influence of ω_2 is insignificant when the angle of nutation θ is very small, but it is important in the tropical zone, where ω_2 is great. The problem of Foucault's pendulum is a special case, when the characteristic of the gyroscope $b = C/A = 0$. [Reference: H. Love, "Higher mechanics," Cambridge, 2nd ed., p. 142.]

D. Rašković, Yugoslavia

2556. Baring, J. A., Stability of controlled processes, *Instruments* **25**, 4, 456–457, 494–497, Apr. 1952.

The factors of greatest importance in controlled-plant stability are (1) amplitude-frequency response, and (2) phase change. The term "plant" refers to any apparatus whose output can be controlled by the variation of the input. An open-loop analysis of the system shows the effect of each.

From author's summary

Vibrations, Balancing

(See also Revs. 2551, 2622)

2557. Eschler, H., On free vibrations in bending of an axially loaded rod with internal and external damping (in German), *Ing.-Arch.* **20**, 1, 1–5, 1952.

Approximate logarithmic decrements and natural frequencies are calculated, essentially by Rayleigh's method by way of Lagrange equations. Contrary to author's assumption, the method should, in the specified form, not adequately produce the overtones.

J. H. Greidanus, Holland

2558. Waller, Mary D., Vibrations of free plates: line symmetry; corresponding modes, *Proc. roy. Soc. Lond.* (*A*) **211**, 1105, 265–276, Feb. 1952.

Paper discusses characteristics of vibration patterns of plates, especially those with symmetry properties. Experimental methods have been used to study different patterns, and the carbon dioxide sublimation method of exciting *free* vibrations has proved very successful. From experimental results, generalizations are made concerning classes of vibration symmetry, and it is shown that a plate with m lines of symmetry may be divided into two times the factors of m classes. It is also shown that the modes of vibration of all plates correspond with one another. Furthermore, it is argued that combined modes can never be obtained in practice unless they conform to symmetry of plate.

Sverker Sjöström, Sweden

2559. Schreuer, E., Thermic damping of elastic vibrations (in German), *Z. Phys.* **131**, 4, 619–628, 1952.

Dissipation of vibratory energy in solids is interpreted, as usual, as an irreversible process of heat conduction from areas of local overtemperature, caused by thermoelasticity, according to Lord Kelvin. Such overtemperature will occur only in cases of compressive elastic energy, whereas cases of shear-strain energy have to be explained otherwise. Author takes account of deviation from the ideal Kelvin process, as caused by harmonic variation of stress and strain, and derives expression for the logarithmic decrement. Author states strain of a vibrating beam to be free of shear and, hence, that its elastic energy could be considered as compressive energy only. As shear-strain energy of a vibrating beam amounts to about 87% of its total elastic energy, reviewer fails to accept this application of author's theory.

Folke K. G. Odqvist, Sweden

2560. Dragilev, A. V., Periodic solutions of the differential equations of nonlinear vibrations (in Russian), *Prikl. Mat. Mekh.* **16**, 1, 85–88, Jan./Feb. 1952.

Paper deals with the existence of periodic solutions of the equation $\ddot{x} + f(x, \dot{x})\dot{x} + g(x) = 0$. First, the special case $g(x) = x$ is considered, and it is found that when the equation $\ddot{x} + f(x)\dot{x} + x = 0$ has a periodic solution, the equation $\ddot{y} + F(\dot{y}) + y = 0$, where $F(u) = {}_0\int^u f(x)dx$, also has a periodic solution. The proof of the theorem stated by Levinson and Smith [*Duke math. J.*, **9**, 1942] is given in the paper under more general assumptions. It is further proved that, if the functions f and g satisfy certain conditions, and when a periodic solution exists for some function f^*, then the periodic solution of the above equation exists, provided $f \geqslant f^*$. This has a simple physical meaning: When a self-oscillatory system oscillates, another self-oscillatory system with greater damping oscillates too.

J. Beránek, Czechoslovakia

2561. Slibar, A., Vibration of parallel-connected or branched engines with nonlinear members (in German), *Maschinenbau Wärmewirtsch.* **6**, 2, 21–27, Feb. 1951.

Author presents a graphical-numerical procedure, utilizing construction of velocity-displacement curves, for the determination of torsional vibration in branched or parallel systems having lumped masses and one or more nonlinear members. A simple numerical example illustrates details of procedure.

J. L. Bogdanoff, USA

Wave Motion, Impact

2562. Lebedev, N. F., On the propagation of a discharge wave in the case of linear stiffness (in Russian), *Prikl. Mat. Mekh.* **15**, 5, 625–628, Sept./Oct. 1951.

Author considers the propagation of waves of unloading in a one-dimensional semi-infinite elastic-plastic medium. The time dependence of the stress at the end of the rod is given, and the stress in the wave front is found as the sum of an infinite series. The method of characteristics is employed, and the stress variation is taken to be sufficiently small so that the stress-strain relation in the plastic region may be approximated by a straight line. If the given stress at the end of the rod varies linearly with time, the series may be summed in closed form.

Richard E. Kronauer, USA

2563. Bishop R. E. D., Longitudinal waves in beams, *Aero. Quart.* **3**, part 4, 280–293, Feb. 1952.

Customary engineering treatment of longitudinal waves in

beams considers only the x-component of tensile stress (reviewer uses x_i, $i = 1, 2, 3$, to mean a Cartesian coordinate; $x_1 = x$ is taken along the axis of the beam. u_i denotes the i-th component of displacement. Conventional meanings are attached to the other symbols), and predicts that the phase velocity at all frequencies is $C_0 = (E/\rho)^{1/2}$. However, L. Pochhammer ["Über die Fortpflanzungsgeschwindigkeiten kleiner Schwingungen in einem unbegrenzten isotropen Kreiszylinder," *J. f.d. reine u. angew. Math.* **81**, p. 324, 1876] and D. Bancroft ["The velocity of longitudinal waves in cylindrical bars," *Phys. Rev.* **59**, p. 588, 1941] have applied exact elasticity theory to cylinders to show that in the first mode the phase velocity actually decreases with increasing frequency, and approaches an asymptote at the speed of surface waves. A. E. H. Love ("The mathematical theory of elasticity," Cambridge, 1927, section 278) and the present author have given engineering treatments which assume that $u_x = u_x(x, t)$, and which initially neglect σ_{yy} and σ_{zz} in the stress-strain relation

$$E\,\partial u_i/\partial x_i = \sigma_{ii} - \nu(\sigma_{jj} + \sigma_{kk}),\ i \neq j,\ i \neq k,\ j \neq k \qquad [1]$$

With this neglect, Love determines u_y and u_z from [1], and integrates the y and z-components of the equation of motion

$$\partial\sigma_{ii}/\partial x_i + \partial\tau_{ij}/\partial x_j + \partial\tau_{ik}/\partial x_k = \rho\partial^2 u_i/\partial t^2,\quad i \neq j,\ i \neq k,\ j \neq k \qquad [2]$$

neglecting the shear stresses, to calculate σ_{yy} and σ_{zz}. By re-use of [1], Love is led to a σ_{xx} which predicts that C falls with increasing frequency from C_0 to zero.

The present author's first treatment uses Love's u_y and u_z, and the resulting shear stresses. The tension stresses are obtained by integrating the y and z-components of [2], in which all terms are retained, and by re-using [1]. This treatment leads, in the case of a cylinder, to a phase velocity which falls monotonically from C_0 to an asymptote at the solenoidal velocity $(\mu/\rho)^{1/2}$ (which, for $\nu = 0.3$, occurs at $0.621\ C_0$, as compared with $0.575\ C_0$ for the first-mode Pochhammer solution).

The author obtains a slightly better approximation by using the previous tension stresses in [1] to calculate improved values of u_y and u_z, which then replace Love's values in a reapplication of the process just described. The resulting phase velocity in the case of a cylinder is bracketed at every frequency by the previous value from above and by Pochhammer value from below.

Author obtains Love's solution as a special case of his treatment, and shows that a slight improvement can be effected by continuing to neglect all shear stresses but iterating after the manner of the last paragraph. The qualitative behavior at high frequencies of the original Love solution is, however, not affected.

Sanford P. Thompson, USA

2564. **Lazutkin, D. F., Propagation of elastoplastic waves along a cylindrical rod** (in Russian), *Prikl. Mat. Mekh.* **16**, 1, 94–100, Jan./Feb. 1952.

Elastoplastic waves are calculated under following assumptions: The rod is of such a length that it is not necessary to take account of waves' reflection from its other end. Pressure on one end, increasing initially in arbitrary fashion, suddenly becomes zero.

Author starts with dividing the portion of the strain-stress curve beyond elastic limit into n parts, each small enough so that each can be replaced by its chord. Longitudinal waves in the rod have then, for each portion, their own velocity which can easily be calculated. Limiting for $n \to \infty$ leads author to his basic relationships [1.20], [1.21]. Theoretical results are illustrated by an example.

The article has both theoretical and practical value.

V. Vodička, Czechoslovakia

2565. **Satô, Y., Seismic focus without Rayleigh-waves,** *Bull. Earthq. Res. Inst., Tokyo Univ.* **29**, 1, 13–20, Mar. 1951.

The waves on the plane surface of a semi-infinite elastic body generated by a dilatational source can, in sufficient distance from the epicenter, generally be separated into three groups: P-waves, S-waves, and Rayleigh waves. Author derives a relatively simple mathematical criterion for a source which does not generate Rayleigh waves and shows how to numerically compute sources of this kind.

Hans L. Oestreicher, USA

Elasticity Theory

(See also Revs. 2576, 2596, 2739)

2566. **Sternberg, E., Eubanks, R. A., and Sadowsky, M. A., On the stress-function approaches of Boussinesq and Timpe to the axisymmetric problem of elasticity theory,** *J. appl. Phys.* **22**, 9, 1121–1124, Sept. 1951.

In the first part of this note, the stress-function approaches of Boussinesq and Timpe to the rotationally symmetric problem in the classical theory of elasticity are referred to general orthogonal axisymmetric curvilinear coordinates. In the second part of the note, a connection between the two stress-function approaches is established.

From authors' summary by H. J. Plass, USA

2567. **Sternberg, E., and Sadowsky, M. A., On the axisymmetric problem of the theory of elasticity for an infinite region containing two spherical cavities,** *J. appl. Mech.* **19**, 1, 19–27, Mar. 1952.

See AMR **5**, Rev. 623.

2568. **Adadurov, R. A., State of stress in a prismatic rectangular box stiffened at the corners and loaded at the ends** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **79**, 3, 407–410, July 1951.

Solution is given for state of stress in a prismatic box having a closed rectangular cross section, formed by orthotropic sheets and four equal and absolutely flexible longitudinal stiffeners located at the corners. Box is continuously stiffened by transverse frames which resist bending in planes of frames but are perfectly flexible in perpendicular direction. Contour of frames is assumed inextensible. Opposite sides of box have same thickness and same elastic properties. Opposite elements of transverse frames are also equal. Thus, transverse sections referred to orthogonal coordinates have double symmetry.

To ends of box are applied skew-symmetric system of loads statically equivalent to zero, causing normal stresses and shearing forces at ends of horizontal and vertical sheets.

Solutions for cases of given displacements at both ends of box, and given stresses and forces at one end of box and displacements at the other end, can be analogously found.

S. Sergev, USA

2569. **Filonenko-Borodich, M. M., Two problems of equilibrium of an elastic parallelepiped** (in Russian), *Prikl. Mat. Mekh.* **15**, 5, 563–574, Sept./Oct. 1951.

Author solved this problem in his previous paper [AMR **4**, Rev. 4094]. Here he shows direct computation of stress components. Solution by separating the variables is possible for a load given by multiplication of two functions of coordinates, as was explained by an example solved in the first paper. Author gives general solution for a load symmetrical to the principal axes of loaded surface and for a nonuniform distribution of tempera-

ture in the body, with a numerical example of a general form of parallelepiped, of a parallelepiped with quadratic bases, and of a cube.
Z. Bažant, Czechoslovakia

2570. Karunes, B., On the concentration of stress in the neighbourhood of a circular hole in a semi-infinite plate, *Indian J. Phys.* **25,** 12, 599–606, Dec. 1951.

A general expression for the stress function in two dimensions was developed in bipolar coordinates by Jeffery [*Phil. Trans. roy. Soc.* 1921]. He applied the general solution to the determination of stresses in a semi-infinite plate with a circular hole, under tension parallel to the straight boundary.

In present paper, author extends the application of Jeffery's solution for the same type of plate to the following two cases: (1) A uniform tension perpendicular to the straight edge; (2) a uniform shear in the plane of the plate. The complete stress function for each case is obtained by superposing Jeffery's general expression on the known stress function at a great distance from the hole, and then evaluating the constants to satisfy the required boundary conditions. The resulting stress distributions around the hole are discussed.
D. H. Winne, USA

2571. Iliffe, C. E., Thermal stresses in a rotating elastic solid of revolution, *Engineer, Lond.* **192,** 5005, 835–846, Dec. 1951.

Author extends Southwell's elastic stress solution to case of steady-state thermal distribution by producing particular integral which accounts for the heating. Results have been formulated for application of relaxation technique.
Max L. Williams, Jr., USA

2572. Green, A. E., Rivlin, R. S., and Shield, R. T., General theory of small elastic deformations superposed on finite elastic deformations, *Proc. roy. Soc. Lond.* (*A*) **211,** 1104, 128–154, Feb. 1952.

Using tensor notations, a general theory is developed for small elastic deformations, of either a compressible or incompressible isotropic elastic body, superposed on a known finite deformation, without assuming special forms for the strain-energy function. The theory is specialized to the case when the finite deformation is pure homogeneous. When two of the principal extension ratios are equal, the changes in displacement and stress due to the small superposed deformation are expressed in terms of two potential functions in a manner which is analogous to that used in the infinitesimal deformation of hexagonally aeolotropic materials. The potential functions are used to solve the problem of the infinitesimally small indentation, by a spherical punch, of the plane surface of a semi-infinite body of incompressible isotropic elastic material which is first subjected to a finite pure homogeneous deformation symmetrical about the normal to the force-free plane surface.

The general theory is also applied to the infinitesimal deformation of a thin sheet of incompressible isotropic elastic material which is first subjected to a finite pure homogeneous deformation by forces in its plane. A differential equation is obtained for the small deflection of the sheet due to small forces acting normally to its face. This equation is solved completely in the case of a clamped circular sheet subjected to a pure homogeneous deformation having equal extension ratios in the plane of the sheet, the small bending force being uniformly distributed over a face of the sheet. Finally, equations are obtained for the homogeneously deformed sheet subjected to infinitesimal generalized plane stress, and a method of solution by complex variable technique is indicated.
From authors' summary by B. E. Gatewood, USA

Experimental Stress Analysis

(See also Rev. 2606)

2573. Bennett, J. A., A study of fatigue in metals by means of x-ray strain measurement, *Proc. Soc. exp. Stress Anal.* 9, 2, 105–112, 1952.

See AMR **4,** Rev. 4099.

2574. Hartman, J. B., and Leven, M. M., Factors of stress concentration for the bending case of fillets in flat bars and shafts with central enlarged section, *Proc. Soc. exp. Stress Anal.* 9, 1, 53–62, 1951.

Factors of stress concentration have been determined photoelastically for the case of a flat bar of width d, containing a central enlarged section of width D and length L, and connected by fillets of radius r, when subjected to pure bending. An additional parameter L/D influences the value of the maximum stress. The factors of stress concentration increase with increasing L/D, attaining an upper bound. Three-dimensional tests have been made to obtain correlation between two- and three-dimensional factors of stress concentration. A novel method of slicing has been developed which allows using a single model for a series of tests. The results obtained have been compared to information obtained by Frocht, and by Petersen and Wahl. Very good agreement is indicated.
R. M. Wingren, USA

2575. Boggis, A. G., Design of differential transformer displacement gauges, *Proc. Soc. exp. Stress Anal.* **9,** 2, 171–184, 1952.

Author cites the advantages of the differential transformer as a nearly linear device transforming mechanical movement into electrical output. Range of motion is $^1/_4$ in. and greater with a-c output up to several hundred millivolts. He derives equations for a typical transformer, stating equations are based on broad simplifying assumptions and are intended as a guide to general design and not as an exact solution. Experimental results show over-all response curves for both balanced and unbalanced windings. Other experimental curves show effect on output voltage of variations in core length, diameter, and composition, and also effect of power-supply frequency. A curve obtained from five transformers having the same number of turns and the same diameter indicates an optimum ratio of length to diameter of about 1.4.
Douglas R. Tate, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 2563, 2608)

2576. Ōkubo, H., Approximate approach for torsion problem of a shaft with a circumferential notch, Ann. Meeting ASME, Atlantic City, 1951. Paper no. 51—A-16, 3 pp. = *J. appl. Mech.* **19,** 1, 16–17, Mar. 1952.

Approximate solutions, using thin-shell and streamline technique, are given for the maximum shearing stress in the case of torsion of shafts of circular cross section with semicircular and semielliptic circumferential notches. Results are shown to compare favorably to exact and approximate solutions, respectively, of Willers and Sonntag.

Additional references: "Mathematical theory of elasticity," by I. S. Sokolnikoff, New York, McGraw-Hill Book Co., 1946, p. 205; "Theory of elasticity," by S. Timoshenko and J. N. Goodier, New York, McGraw-Hill Book Co., 2nd ed., 1951, p. 304 (or first edition thereof).
E. W. Suppiger, USA

2577. **Pollock, P. J., and Alexander, G. W., Dynamic stresses in wire ropes for use on vertical hoists,** "Wire ropes in mines"; *Proc.* Conf. Ashorne Hill, Sept. 1950, Instn. Mining Metall., London, 445–462, 1951. $7.

Employing Laplace transform, author solves the equation of motion of an elastic rope of free length L and mass mL, supporting a cage of mass M at the bottom and moving vertically downward when a deceleration is applied at the top by means of brake drum. Then he obtains expressions for dynamic tensions in cases of constant rate and steadily increasing rate of deceleration, etc., damping and change of length of rope during the braking period being neglected. Perfect reflection of stress waves at the drum has been assumed.

Author deduces that anything in the nature of a shock or sudden change of acceleration is undesirable and that a definite maximum rate of deceleration, limited by governing, is preferable to a gradual but steady increase of the rate of deceleration up to the instant when the drum is brought to rest and the deceleration suddenly falls to zero. Analysis also shows that the most favorable building-up period under a steady increase of rate of deceleration is t (necessarily less than the total braking period) $= 2\pi L/(c\lambda_1)$, the fundamental period of oscillation of the system, where c is the velocity of stress propagation in the rope and $\lambda_1 \tan \lambda_1 = mL/M$, and, further, this rate of deceleration attained, having been kept steady for a suitable period, should be gradually reduced to zero over a similar period of time to similar advantage. Numerical practical data are taken to elucidate and correspond closely with the analysis made. Author believes that his analysis is an improvement on that of J. Perry and D. Smith [*Proc. Instn. mech. Engrs.* **123**, p. 537, 1932]. Tensions at the bottom of the rope, which are considered more important, are also obtained in cases of dropping a load into a hanging skip, skip loading with varying load, and pickup from rest.

D. N. Mitra, India

2578. **Almen, J. O., Torsional fatigue failures,** *Prod. Engng.* 22, 23; 9, 3; 167–182, 168–174; Sept. 1951, Mar. 1952.

The suitable elimination of failures presumes the right diagnosis of the failure cause. Direction, shape, and structure of the fracture often give important information in this respect. Paper treats only torsional fatigue failures with a profoundness and completeness not reached before. In a former article [title source, 101–124, March 1951], author showed that fatigue failures are tensile failures. This knowledge is used successfully in examining fatigue failures of coil springs and torsion bar springs. The influence of residual stresses, which are produced by presetting and shot-peening, to increase the strength, and the sequence in which these operations were applied, are theoretically and experimentally examined. A new torsional stress diagram is developed for analysis of surface and subsurface stresses. Application is shown by practical examples. Paper is of high value for spring makers, technologists, and designers.

Pavel Kohn, Czechoslovakia

2579. **Wiesner, E., Quick determination of slopes and deflections by means of the MacLaurin series** (in German), *Bautechnik* 29, 1, 12–14, Jan. 1952.

Paper considers the problem of determining the deflections of a simple beam with end supports. To avoid solving the fourth-order differential equation by lengthy repeated integrations, Wiesner's solution is in the form of a MacLaurin series about a point of support. The boundary conditions on the derivatives of the deflection are functions of moment, shear, and unit loading. The method gives the slopes and deflections for a number of cases of symmetrical and antisymmetrical loading.

Howard H. Dixon, USA

Plates, Disks, Shells, Membranes

(See also Revs. 2570, 2572, 2595, 2610, 2623)

2580. **Spampinato, A. R., Influence of precompression of outer edges on transverse moments in a barrel vault shell** (in Spanish), *Cienc. y Técn.* **117**, 594, 250–256, Dec. 1951.

Short statement of the essential ideas of barrel-vault theory. Results of computations (bending moment M_φ) for an example, varying systematically one boundary condition on the straight edges: either $N_{x\varphi} = 0$, or $\partial u/\partial x = 1.5 \cdot 10^{-4}$ or $= 0$, or N_x equal to a large negative value (using the usual notations).

W. Flügge, USA

2581. **Federhofer, K., Stresses in slightly bulged cylindrical containers** (in German), Alfons Leon Gedenkschrift Verlag Allg. Bau-Z., Wien = *Öst. Bauzeitschr.* **6**, 9, 149–153, 1951.

Paper deals with thin shells of revolution in which the angle between the axis of revolution and the normal to the meridian line differs only slightly from $\pi/2$. State of stress is split up into membrane stresses and bending stresses (equations of Reissner-Meissner), and all solutions are developed into power series of a parameter $\mu \ll 1$. $\mu = 0$ corresponds to the circular cylindrical shell. Author assumes a flat parabolic arc as the meridian line, and retains the first powers of μ only. All solutions can then be given in closed form.

Heinz Parkus, Austria

2582. **Mezhlumyan, R. A., Determination of the bearing capacity of thin-walled structures taking into account the material-hardening** (in Russian), *Prikl. Mat. Mekh.* **15**, 2, 175–182, Mar.–Apr. 1951.

Paper continues consideration of author's previous works [AMR **4**, Revs. 3514, 4118]. After analyzing the stresses in the thin-walled structure, its bearing capacity may be determined either by neglecting the material-hardening or taking it into account. The first method of calculation is simpler, but for hardenable materials it may lead to errors. Considering the second method, author bases the calculation on the assumption that the loading of the thin-walled structure is elementary, the relationship between the intensity of stresses and intensity of strains is based on the experimental tests, and the volume strains are elastic. Author studies the distribution of forces and moments in the thin-walled structure out of the limit of elasticity and the determination of bearing capacity. The problem is posed in a general manner and it seems to regard the aeronautical problems.

Witold Wierzbicki, Poland

2583. **Pawelka, E., Elastic behavior of commutator linings** (in German), *Elektrotech. Mashinenb.* **69**, **6**, 135–140, Mar. 1952.

Deformations of commutator linings due to the (uniform) pressure exerted on the commutator ring and the membrane stress variation along the length of the lining are treated. Commutator lining is considered an aeolotropic cylindrical shell whose radial and longitudinal elastic properties differ because of mica lining of copper cylinder. Temperature stresses and abrupt variations in thickness are included in the treatment. In view of the fact that the stress concentration at the thickness change is not considered, reviewer feels that this aspect of the solution can only be regarded as a first approximation.

Engineers engaged in mechanical design of large electrical equipment will find this paper useful and interesting. Cases which arise in practice are tabulated, and a numerical example is worked.

Lawrence E. Goodman, USA

2584. Wang, C.-T., Principle and application of complementary energy method for thin homogeneous and sandwich plates and shells with finite deflections, *NACA TN* 2620, 33 pp., Feb. 1952.

Author shows how the principle of minimum complementary energy for large deflections of flat plates can be derived from the principle of minimum potential energy by a procedure known as "Friedrichs' method" of the calculus of variations. The method is then applied for thin homogeneous and sandwich cylindrical shells to derive stress-strain relations appropriate to the assumed equations of equilibrium for these structures. Terms which have not been taken into account previously appear in the stress-strain relations, and it is not at all obvious that these additional terms are necessarily small compared with those previously retained. The method of Friedrichs is thus shown to be very useful in problems where the investigator's intuition is apt to lead him astray.

Paul Seide, USA

2585. Gaydon, F. A., On the combined torsion and tension of a partly plastic circular cylinder, *Quart. J. Mech. appl. Math.* **5,** part 1, 29–41, Mar. 1952.

Particular combinations of twist and extension of a solid circular cylinder are considered. The Reuss equations are used throughout, and these are integrated, for different cases, to give the shear stress and tension in the plastic material. It is shown that the stresses rapidly approach their asymptotic values and are within 1 or 2% of these values when the plastic strains are still of the same order as the elastic strains. A more general case, in which the twist and extension are such as to make the ratio load to torque constant, is solved numerically. Finally, the residual stresses are evaluated, after partial unloading, for a bar which has been twisted and extended in constant ratio.

From author's summary by C. B. Matthews, USA

2586. Chwalla, E., On the problem of the effective width of cover plates and reinforced plates (in German), Alfons Leon Gedenkschrift, Verlag Allg. Bau-Z., Wien, 31–35, 1952.

Author uses an approximation method (based on minimum potential energy) developed by Eric Reissner to calculate the influence of the shear lag on the stress distribution and on the deflection in cover and reinforced plates. Assuming that the load is only a function of x, where the x-axis is in the direction of the supporting columns, a differential equation of the sixth order for the deflection is derived. From the solution of this equation, it is possible to calculate the displacements of the plate in the direction of the x-axis. A formula for the effective width is given. Author will publish numerical results.

J. W. Cohen, Holland

Buckling Problems

(See also Revs. 2597, 2603)

2587. Suenson, E., Strength and compressibility of brick columns when every other brick is strong and every other weak (in Danish), *IngenVidensk. Skr.* no. 1, 103 pp., 1951.

Paper contains a research report on experiments on the strength of bricks and brick columns made at the Laboratory for Building Research at the Danish Royal Technical College in Copenhagen. In part I, preliminary experiments are described concerning the uniformity of ordinary bricks as they are delivered from the producer, and the possibility is discussed of giving a quick-working procedure by means of which a uniform strength of the bricks can be secured. Author concludes that the length of the bricks is here of importance, and advises that the longest as well as the shortest ones be left out. Part II gives a very detailed description of the experiments made on brick columns. The test specimens were square columns of 1 stone width and 10 layers high. At the top and bottom they were supplied with a steel plate 1.8 cm ($^3/_4$ in.) thick, to secure a uniform pressure during the test. All specimens were tested to collapse. A formula for the strength of columns with lime mortar as well as with cement mortar is deduced in such a form that only the strength of the different bricks to be used appears as independent variables.

Reviewer agrees with author when he points out that the experimental basis for the deduction seems to be weak, the total amount of columns tested being 32, and the ratio between the strength of the bricks being the same throughout the whole program. The paper seems, however, to be a good guide when further investigations are to be made.

Leif N. Persen, Norway

2588. Kerekes, F., and Nedderman, W. H., Secondary buckling in hollow rectangular column sections of steel plates, *Iowa Engng. Exp. Sta. Bull.* no. 171, 56 pp., Nov. 1951.

Paper reports experimental results of secondary buckling of 19 hollow square and rectangular column sections fabricated under usual shop methods from a single mild structural steel plate with one longitudinal welded joint along the center of one side. Critical buckling stress of square columns whose side plates have width thickness ratios b/t between 20 and 80 is given as

$$\sigma = 5b^2/t^2 - 1080b/t + 71{,}000$$

Critical buckling stress of rectangular column with b/d ratio of 0.6 and with side plates having b/t ratios between 40 and 80 is given as

$$\sigma = 6.1b^2/t^2 - 1025b/t + 65{,}000$$

These results are compared with the theoretical Bryan loads, Timoshenko's large-deflection theory, and von Kármán's equivalent-width method. The effects on buckling strength of the side plates due to initial irregularities, round corners of the cross section, and amount of edge support are also investigated

Minglung Pei, USA

2589. Lo, H., Crate, H., and Schwartz, E. B., Buckling of thin-walled cylinder under axial compression and internal pressure, *NACA Rep.* 1027, 9 pp., 1951.

See AMR **4,** Rev. 167.

2590. Reinitzhuber, F., Stability of straight rods with linearly varying longitudinal force in the inelastic region (in German), Alfons Leon Gedenkschrift, Verlag Allg. Bau-Z., Wien, 18–22, 1952.

Numerical results for the title problem are found on the basis of the following assumptions: (1) The local bending stiffness of the column is the Engesser weighted mean of the tangent and elastic moduli; (2) the tangent modulus varies linearly from the elastic value at the elastic limit to zero at 1.25 times the elastic limit; (3) the deflected shape is a half sine wave.

S. B. Batdorf, USA

2591. Hahn, L., Buckling of circular rings in elastic surroundings (in French), *Publ. int. Assn. Bridge struct. Engng.* 11, 227–246, 1951.

The critical compressive load of a circular ring subjected to a constant pressure is obtained theoretically. The elastic medium in which the ring is embedded is such that it offers a resistance in proportion to the outward displacement (elongation of the radius of the ring), but induces no resistance if the displacement

is inward. Reviewer believes that the problem so formulated is novel. Y. C. Fung, USA

Joints and Joining Methods

(See also Revs. 2634, 2638, 2639)

2592. **Koenigsberger, F., Design stresses in fillet weld connexions,** *Instn. mech. Engrs., appl. Mech.* **165** (W.E.P. no. 66), 148–157, Proc. 1951.

Paper suggests a method of determining the working loads of eccentrically loaded fillet welded joints by working out the stresses in the plastic state prevailing immediately before failure occurs. The results of this calculation are represented in graphs. Practical experiments gave results which were in close agreement with the results of these calculations. As with other methods presently in use, the method described is not applicable to fatigue loaded weld connections. Tensile tests with fillet welded connections joining rolled angle sections to gusset plates showed that the welds failed almost at the same load and that there was no influence of the arrangement of the welds, if the total throat area in each test was the same. This would suggest that the force transmitted by each weld is proportional to the cross-sectional area of its throat. Tensile tests with Huggenberger extensometers attached to the angles showed that bending occurs in the angles. The plate of the bending stress near the end of the welds is more pronounced with equal welds than if the welds are arranged in such a way that the centroid of the area of the weld throats coincides with the centroid of the angle section.

E. Siebel, Germany

Structures

(See also Revs. 2584, 2629)

2593. **Zaytseff, S., The Hardy Cross method and its simplifications [La méthode de Hardy Cross et ses simplifications],** Paris, Dunod, 1952, 88 pp., 36 figs. 560 fr. frs.

This work is a primer of moment distribution as applied to prismatic sections. In addition to the classical procedure of distributing unbalanced fixed-end moments, the author considers the alternate method of distributing deformations and also the well-known technique of shear distribution in frames with sidesway. Although none of the material is new, the excellent examples make this a useful text. William J. LeMessurier, USA

2594. **Wehle, L. B., Jr., and Lansing, W., A method for reducing the analysis of complex redundant structures to a routine procedure,** *Fairchild Publ. Fund, Inst. aero. Sci.* Prepr. no. 367, 22 pp., 20 figs., Feb. 1952.

Paper states the equations for analysis of redundant structures in matrix notation. Formal solution is carried out and a numerical example of a simplified swept-wing structure given.

W. S. Hemp, England

2595. **Kappus, R., The "scheme of the homogeneous field," rectangular or oblique** (in French), *Rech. aéro.* no. 23, 51–60, Sept.–Oct. 1951.

The usual idealization of a sheet-stringer structure consists of concentrated edge members (stringers plus effective sheet) bounding a panel considered effective in resisting only shear stresses which are constant within each panel. Author states that this simple scheme gives satisfactory accuracy with rectangular panels, but that it is unsuitable for nonrectangular panels arising in sweptback wing structures.

By supposing the panel to carry uniform direct stresses acting parallel to its sides as well as the uniform shear stress, author obtains a more suitable idealization for nonrectangular panels. He shows by a numeric example calculated by the old (pure shear panel scheme) and the new (homogeneous stress panel scheme) that the latter method is also more accurate in the case of a structure composed of rectangular panels.

Reviewer notes that author's idealization is but one of several possible elastic network or finite difference approximations to the behavior of a nonrectangular sheet-stringer panel. Fundamental test of whether a particular scheme is suitable is that it should, when taken to the limit (panel sides infinitesimals), represent the elastic behavior of the plate exactly. Author's homogeneous stress-panel scheme would satisfy this test, whereas the pure shear-panel scheme does so only if panels are rectangular and Poisson's ratio is zero. P. C. Dunne, England

2596. **Falkenheiner, H., Systematization of redundancy calculations according to the hypothesis of the "scheme of the homogeneous field"** (in French), *Rech. aéro.* no. 23, 61–65, Sept.–Oct. 1951.

On the basis of work given by R. Kappus (see preceding review), redundancy calculations for stressed-skin construction are systematized by use of matrix calculus. The method is applicable to rectangular as well as oblique structures.

J. R. M. Radok, England

2597. **Baker, J. F., and Roderick, J. W., Tests on full-scale portal frames,** *Proc. Instn. civ. Engrs.* **1**, 1, part I, 71–94, Jan. 1952.

Tests on six single-story, single-bay steel frames, loaded to produce fully plastic moments in certain regions, are described. Frames were constructed of 8-in. × 4-in. I-type sections, were 16 ft wide and 8 ft high, and were subjected to a central vertical load plus a horizontal load at beam level. Frames were tested in pairs to provide mutual lateral stability. Two frames had pinned bases and failed by instability of column flanges at a load 2% above that predicted by simple plastic theory. Remaining four frames had fixed bases. Two of these withstood 16% more than calculated collapse load for three days without collapsing completely, although creep was noticeable. Last two frames failed in welds at 12% above calculated collapse load. Authors suggest that extra strength of fixed-base frames was due to strain hardening. John E. Goldberg, USA

2598. **Neal, B. G., and Symonds, P. S., The rapid calculation of the plastic collapse load for a framed structure,** *Proc. Instn. civ. Engrs.* **1**, 1, part III, 58–71, Apr. 1952.

Paper deals with analysis of rigidly jointed steel frames of ductile material, and is the most powerful and rapid method of calculation of plastic collapse load to be published to date. Technique consists in combining independent mechanisms of local collapse to give the smallest collapse load, and hence at any stage the collapse load is bounded from above. The number of independent mechanisms is equal to the number of independent equations of equilibrium, and can be found easily by inspection of frame. A two-bay three-story frame subject to distributed and point loads is given as an illustrative example. (Author claims 20 minutes for complete solution.)

Jacques Heyman, England

2599. **Holmberg, Å., Two highway bridges with high-grade steel reinforcement,** *Publ. int. Assn. Bridge struct. Engng.* **11**, 247–252, 1951.

A description is given of two reinforced-concrete bridges provided with high-grade steel reinforcement ($\sigma_{Y.P.} \approx 100{,}000$ psi)

The use of Forssell's anchoring rings for the anchorage of the reinforcement bars has permitted high allowable stresses, which have resulted in small dimensions and economical structures.

From author's summary

2600. Langefors, B., Structural analysis of sweptback wings by matrix transformation, *SAAB Aver. Co., Linköping TN* 3, 72 pp., 1951.

A procedure is given for the routine calculation of stress and deformations of redundant structures by matrix methods. A scheme is given for matrix multiplication by punched-card machines. Applications are made to sweptback wings.

A. Devinatz, USA

2601. Hall, A. H., Derivation and application of a general formula for directly computing the skin thickness of wings and tailplanes, *Nat. aero. Establish. Canada Rep.* 12, 24 pp., 1951.

A formula is proposed, giving skin thickness in terms of torsional stiffness and main structural parameters, containing coefficients for a coarse, empirical correction to ordinary theory.

P. Cicala, Argentina

2602. Lindquist, D. C., Effects of wing lift and weight on landing-gear loads, *NACA TN* 2645, 42 pp., Mar. 1952.

Experimental results for drop tests of a constant orifice landing-gear strut are presented in graphical form. Various predetermined constant forces were applied to a weighted landing gear by means of a pneumatic device, and maximum accelerations of the mass were measured for several drop heights with several mass configurations. Reviewer would like to have seen included a comparison between the presented results and those determined analytically in studies by Floor [AMR 2, Rev. 828].

T. F. O'Brien, USA

2603. Cowan, H. J., Direct design of rectangular columns with bending about an axis of symmetry, *J. Amer. Concr. Inst.* **23**, 6, 465–484, Feb. 1952.

Method is limited to case when depth to neutral axis is less than the effective depth of the section, and is based on the usual assumptions of elastic theory of reinforced concrete as applied to cracked sections. Chief difference from usual design procedure is assumption of neutral axis-depth ratio from which may be calculated the section dimensions based on the maximum permissible stresses of the materials. Rules are given for determining depths to the neutral axis for several cases of sections with tensile reinforcement only or with symmetrical reinforcement. Author claims time-saving in finding an economical column section.

Gordon P. Fisher, USA

2604. Hajnal-Kónyi, K., with discussion by Baker, A. L. L., Tests on concrete beams reinforced with 12 gauge wires of an ultimate strength of 120 tons per sq. in., *Mag. Concr. Res.* no. 9, 113–129, Mar. 1952.

Tests to failure are reported on two 8 in. × 18 in. beams reinforced with 28 untensioned wires of #12 gage and 269-ksi ultimate strength. This steel was designed to give about the same total ultimate tensile strength as would have been provided by the yield-point strength of an economic percentage (1.26%) of mild steel. The beams developed large deflections, nearly 2 in. on an 11-ft span under third point loading. Closely spaced cracks (average spacing 3.5 in.) developed, the widest prior to failure being of the order of 2 mm. Both beams failed suddenly by fracture of the steel at calculated steel stresses by plastic theory of 284 and 294 ksi, or approximately 6% and 9% in excess of the wire ultimate strength.

Author contends that Professor Baker's theory grossly underestimates capacity of beams in which wires are bonded and not prestressed. Professor Baker points out that the excess in these tests is within the normal experimental variation.

Phil M. Ferguson, USA

2605. Schwertner, A., Tests to determine the distribution of stress on the surface of steel in reinforced concrete (in German), *Acta Techn. Hung., Budapest* **2**, 2/4, 303–344, 1952.

Paper discusses distribution of bond stress on reinforcement in concrete. Tests were done on one column 4 m long, one column 1 m long, and numerous pull-out specimens with varying lengths of embedment. Theory assumes that bond stress is proportional to the difference in deformation when both steel and concrete are loaded and deformation when steel alone is loaded. No justification for this assumption is given. Tests are all short-time and no account is taken of gradual transfer of load on concrete to steel. Strain measurements on first specimen were too scattered to allow conclusions to be drawn. Measurements on the short column were more uniform, but the position of reinforcement right at edge of column makes the usefulness of conclusions drawn in this case open to doubt.

Finally, the theory is applied to bond distribution in bonded prestressed members.

Frank A. Blakey, Australia

2606. Kuhn, R., Dimensioning of reinforced-concrete structure by means of photoelasticity (in German), *Bauingenieur* 26, 6, 7; 177–181, 205–207; June, July 1951.

Author describes a photoelastic model test made to give dimensioning rules for a wall above the draft tube in a planned water power station at "Limbach der Rhein-Main-Donau A G." He considers the concrete wall as elastic and takes the tensile stresses, designed from the theory of elasticity—by means of the model tests—with the reinforcement. The investigation seems to be accurate and the design on "the safe side." In a concrete construction, however, there are many other possibilities for arranging the reinforcement. Reviewer is, therefore, of the opinion that further investigations by means of photoelastic model tests taking into account the effect of cracks should be of value in this and similar cases.

Henrik Nylander, Sweden

2607. Smirnoff, M. V., Analytical method of determining the length of transitional spiral, *Proc. Amer. Soc. civ. Engrs.* Dec. 1949 = *Trans. Amer. Soc. civ. Engrs.* **116**, 155–185, 1951.

Author's equation considers: Speed v, radius R, centrifugal over-acceleration C, and transverse superelevation e of transition curve. C is assumed to be constant; introduction of e allows shorter spiral lengths. A table gives comparative resulting values. Eight authorities take part in the discussion. (1) Mr. Hickerson considers formula to be better than usual one, but he disagrees with "comfort criterion" as a guide for length estimation. (2) Mr. Klingel prefers two independent formulas: one for maximum e design; other for maximum remanent unbalanced centrifugal forces. (3) Mr. Meyer disagrees with author's frictionless development, but he recognizes importance of C. (4) Mr. Barnett disregards importance of mathematical curves and defends their spline drawing adopted in Westchester County, N. Y. He considers author's approach to be correct. (5) Mr. Lemming denies that C may give criterion for transition design and calls it a meaningless formula. (6) Mr. Tyson refers to British practice which balances lower C's with higher e's, and he shares author's criterion about constant C when not greater than 1.00 ft sec^{-3}. (7) Mr. Thompson concludes, through formulas and graphs, that drivers may create their own transitions without leaving circular lanes if road presents a shift, say P, less than 1 ft (P is the distance between unspiraled curve and the offset one

derived by transition considerations). For greater shifts, Mr. Thompson proposes two separate formulas for below and over 60-mph speeds. They take implicit account of both C and e. (8) Mr. Meyer accepts formula as a refinement and an important contribution, but he thinks that car-steering conditions are as important as those based on force analysis. Finally, author answers that the question may be approached from different angles, but he supports: (a) Constant C is an acceptable convention, and as much as that of constant design speeds; (b) lateral friction factor may be employed rather to determine circular radii than transition lengths. It is a widely uncertain factor; (c) rotational effects of cars are implicit in C assumptions; (d) small values of shift P and transitions short enough to be unnecessary are same concepts; (e) correct spirals eliminate driver tendency to cross lanes.

Author's most important conclusions are: (1) for $C = 1.35$ ft sec^{-3}; spiral length S and final radius R in ft; speed V in mph; e dimensionless transverse superelevation rate, his formula becomes $S = 2.33\ V^3/R - 35Ve_{\max}$; (2) if second term is greater, it must be taken as total length; (3) transition curve is unnecessary if length is shorter than 150 ft; (4) if spiral is omitted, second term may be used to determine length of superelevation runouts on tangents. J. E. Carrizo Rueda, Argentina

2608. Goded Echevarría, F., Beams and arches of circular contours with uniform loads. Exact solutions by means of the theory of elasticity (in Spanish), *Inst. téch. Constr. Cem.* no. 107, 113 pp., Jan. 1951. 25 ptas.

In the first part of this publication a pair of general two-dimensional elasticity problems, involving curvilinear boundaries, are solved by inversion through the use of Michell's theorem. Body forces are taken as zero. A wedge subjected to equal, uniformly distributed, normal compressions and to a concentrated force at the vertex is taken as the original body, and its state of stress determined. The state of stress is then obtained for the two desired cases whose contours are obtained by inversion of the original contour. Taking any point inside the wedge as the center of inversion, the two limiting straight lines of the wedge become two circles. After the inversion, two unequal, uniformly distributed normal compression forces act on the circles.

In the second part the same general problems, but with two equal moments of opposite sign acting at the vertexes, are solved. Inversion leads to a condition of moment at the center of one circle only, and to two equal pressures of opposite sign.

By changing the angle of the wedge and the location of the inversion pole, various positions of the circles are obtained, and this leads to a number of specific solutions. Applications are made to beams of lenticular and semilenticular longitudinal profile; to plates of cylindrical, semicylindrical, and figure-of-eight shape, loaded along their edge; and to tunnels, circular holes in plate, and a two-hinged, crescent-shaped arch.

James Michalos, USA

2609. Chien, N., Feng, Y., Wang, H.-J., and Siao, T.-T., Wind-tunnel studies of pressure distribution on elementary building forms, Iowa Inst. Hydr. Res., State Univ. Iowa, 133 pp., 1951.

Wind-tunnel studies on a large number of small-scale building models are reported for wind directions along each axis of buildings and at 45° (some at 30° and 60°). A wide range of lengths and heights are covered for buildings with flat roofs (without overhang or parapet), with gabled roofs sloping at 15°, 30°, and 45°, and with semicircular hanger-type roofs. Thin vertical walls are also studied, as well as some cases showing the effect of adjacent identical structures. Piezometer measurements were made at close enough spacing to yield pressure contours on all surfaces.

Pressure contours for all cases are presented to large scale (88 pages), but a comprehensive series of curves also summarize such factors as maximum local negative pressures, maximum average negative pressures, coefficients of lift and drag, centers of pressure, and average pressures. Phil M. Ferguson, USA

2610. Vlasov, V. Z., Lightened space structure forms of hydrotechnical structures and methods of their calculation (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 10, 1443–1482, Oct. 1951.

Author points out economical importance of space structure forms in hydrotechnical objects and gives detailed methods, based primarily on his previous work, for approximate stress calculations on cylindrical shells and on flat shells with double curvature [see AMR **4**, Rev. 2418]. Sector control gates are treated as open cylindrical shells, whose transversal sections remain undistorted. Twisting moments of external forces about flexural center are taken up mainly by stresses due to prevented warping of sections (similar treatment in: Wagner-Pretsch, "Verdrehung und Knickung offener Profile," *Luftfahrtforschung*, 1934). Broad supporting walls and dams are treated similarly by decomposing into long narrow shells and supposing that edges between them remain straight. Differential equation for transversal bending moment in the edge of two shells is of the same type as for moments in beams on elastic foundation.

Spillways and other closed cylindrical shells with or without partition walls are treated by author's variational method, and its basic equations are given. It reduces number of independent variables to one, using known results of theory of plane frames. Spillway with A-section is treated both on stiff and elastic foundation.

Basic equations for flat double-curved shells with two Cartesian coordinates as independent variables are applied to stress determination in a multiconnected supporting wall, both under the action of hydrostatic pressure and of unequal temperature distribution. Close analogy between formulas for internal stresses is found in both cases. Stresses in large propeller turbine blades are determined in the same way.

Author's methods allow a simpler treatment of shells, and a comparison of results with classical theory would be of interest.

Anton Kuhelj, Yugoslavia

2611. Michalos, J. P., and Wilson, E. N., Influence lines by corrections to an assumed shape, *Proc. Amer. Soc. civ. Engrs.* **78**, Separ. no. 124, 15 pp., Apr. 1952.

Paper demonstrates application of method of balancing angle changes to determination of influence lines for continuous structures by means of Müller-Breslau principle. End displacements of the several spans are computed by iterative angle-change procedure. Intermediate displacements are then computed by using influence values for fixed-end moments of each span. Since constants are available elsewhere for wide range of members with variable I, method is directly applicable to structures containing such members. Reviewer believes that slope-deflection method leads to an equally convenient procedure for structures of many spans and has the advantage of direct algebraic solution if number of spans is small. John E. Goldberg, USA

2612. Soete, W., Possibilities of prestressing metallic structures (in French), *Rev. Soudure* **7**, 4, 205–213, 1951.

Author discusses purposes and requirements of prestressing steel structural members. He considers the two types of methods: (1) Prestressing by external agencies (as by tension bars or cables); and (2) prestressing consisting of systems of self-equili-

brating stresses in the member itself. He suggests, as an external agency for prestressing, the use of a slab of concrete. This would be poured on the tension flange of the beam while the latter is loaded in simple bending. After setting of the concrete and removal of the load on the beam, the concrete slab is in compression which maintains the initial state of bending in the beam. Tests carried out by author show that a beam prestressed in this manner had its proportional limit increased by 72%. Under the second type of method, author suggests schemes for producing favorable distribution of internal stresses by differential heating. Tests show that theoretical advantages of this type of prestraining will be very difficult to obtain. Economic comparisons are not presented in connection with either of the new methods suggested.

P. S. Symonds, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 2564, 2582, 2619, 2620, 2625, 2627, 2632, 2636)

2613. Opinsky, A. J., and Smoluchowski, R., The crystallographic aspect of slip in body-centered cubic single crystals. II. Interpretation of experiments, *J. appl. Phys.* **22,** 12, 1488–1492, Dec. 1951.

Theoretical considerations of part I [AMR **5,** Rev. 2033] are applied to earlier experimental data obtained by Fahrenhorst and Schmid, Taylor and Elam on iron and beta-brass and to new data of authors on silicon ferrite. Measurements of yield strength are not too satisfactory for investigation of slip behavior; determination of slip plane and orientation of tensile axis give useful results. It is found that ratio of critical shear stresses on {123} and {112} is close to 1, independent of temperature, but that ratio on {123} to {110} is generally > 1 and changes with temperature and composition.

Albert Kochendörfer, Germany

2614. Gebhardt, E., and Wörwag, G., Viscosity of liquid alloys silver-copper-gold (in German), *Z. Metallk.* **43,** 4, 106–108, Apr. 1952.

Viscosity measurements are reported for melts of the ternary system silver-copper-gold at various concentrations, and at four temperatures from 1000 to 1300 C. All viscosity-concentration curves are regular and give no evidence of any structural changes in the liquid state.

From authors' summary by M. Mooney, USA

2615. Nadai, A., Strain-hardening and softening with time in reference to creep and relaxation in metals, *Trans. ASME* **74,** 3, 403–413, Apr. 1952.

The stress-strain relations are for uniaxial state of stress. A simple relation between permanent strain and stress mentioned by the author is $\sigma - (\sigma_0 + \chi t) = \psi\epsilon'' + \phi\,\dot\epsilon''$, where ϵ'' is the permanent strain, χ, ψ, and ϕ material constants, and σ_0 the yield stress at time $t = 0$. A first generalization is to suppose that χ, ψ, and ϕ are functions of time and several more complex relations $F(\sigma, \epsilon'', \dot\epsilon'', t) = 0$ or $F(\sigma, \epsilon'', \dot\epsilon'') = 0$ are used. To the permanent strain is added an elastic strain $\epsilon' = \sigma/E$. Expressions for change of strain after initiating a constant stress (creep) and for change of stress after initiating a constant total strain (relaxation) are derived.

Besides the strains ϵ' and ϵ'', a strain ϵ''' obeying the law $\sigma = E_s\epsilon''' + 3\mu_s\dot\epsilon'''$ is supposed, the total strain being $\epsilon = \epsilon' + \epsilon'' + \epsilon'''$. The expressions with ϵ' and ϵ''' hold for all values of σ or $\dot\sigma$ and, because of this, they need not be special forms of the afore-mentioned linear relation with ϵ''.

The strain ϵ''' is called recoverable strain. At the moment of initiating a constant stress which does not cause a strain ϵ'', the total strain is $\epsilon = \sigma/E$, and in the position of final equilibrium $\epsilon = \sigma(1/E + 1/E_s)$. It may be pointed out that in some problems only strains of the type ϵ''' play a role. Reiner [AMR 4, Rev. 1159] treats the case of a vibrating steel spring stressed below the elasticity limit, and the stress-strain ($\epsilon = \epsilon'''$) relation is in Nadai's notation $\sigma = E_s\epsilon''' + 3\mu_s\dot\epsilon'''$, E_s being the elasticity modulus. As to the strain ϵ', also called recoverable strain, it may be said Nadai supposes that a part of the recoverable strain follows the stress immediately and the other part follows the stress with retardation, and Reiner supposes for his special case that the total recoverable strain follows the stress with retardation.

Creep and relaxations functions are computed for materials with the three types of strain, ϵ'' following from the relation for viscous liquids $\sigma = 3\mu\,\dot\epsilon''$. Also the way to solution is shown for ϵ'' according the relation $\sigma = \psi\epsilon'' + \phi\,\dot\epsilon'' + \chi t$.

J. P. Benthem, Holland

2616. Brinkman, H. C., The viscosity of concentrated suspensions, *J. chem. Phys.* **20,** 4, p. 571, Apr. 1952.

Einstein's viscosity equation for very dilute suspensions is generalized to the approximation $\eta = \eta_0(1 - c_v)^{-5/2}$ for concentrated suspensions by considering the effect of the addition of one solute molecule to an existing solution, which is considered as a continuous medium.

M. Reiner, Israel

2617. Jaswon, M. A., and Foreman, A. J. E., The non-Hookean interaction of a dislocation with a lattice inhomogeneity, *Phil. Mag.* **43** (7), 337, 201–220, Feb. 1952.

Authors elaborate a procedure for calculating the external shear τ required to hold edge dislocations of Peierls-Nabarro type [R. E. Peierls, *Proc. phys. Soc.* **52,** 34, 1940; F. R. N. Nabarro, idem., **59,** 256, 1947] in equilibrium at prescribed distances from certain types of lattice inhomogeneities. Their formulation of the problem of the interaction of dislocations with lattice inhomogeneities reduces the above calculation to the following question: To compute τ for a Nabarro-Peierls dislocation "when the atomic structure along the slip plane is no longer constant but varies in a specified manner." Mathematically speaking, this is equivalent to solving a certain nonlinear integral equation for the shear stress along the slip plane of interest.

Authors consider the following physically interesting problems involving a single dislocation of this type: (1) Its interaction with a Zener microcrack [Zener, *Phys. Rev.* **69,** 128, 1949]; (2) with a grain boundary; (3) with an inhomogeneity consisting of a layer of crystalline material with different lattice parameters. They also formulate and solve approximately the problem of an array of collinear edge dislocations held immobile before a barrier by an appropriate τ.

Albert W. Sáenz, USA

2618. Marshall, E. R., and Shaw, M. C., The determination of flow stress from a tensile specimen, *Trans. Amer. Soc. Metals* **44,** 705–720, 1952.

An experimental study was made of the influence of neck profile on the true-stress true-strain curve obtained from tensile tests of SAE 4140 steel and annealed electrolytic copper. The experimentally observed neck profile radius was used to correct for the effects of the neck on the true-stress true-strain curve. The results of some cutting experiments on copper were used to illustrate the manner in which tensile data may be applied to a problem in the region of large plastic strain.

The relationship, which was found by P. W. Bridgman [*Trans. Amer. Soc. Metals* **32,** p. 553, 1944], between the uniform flow stress σ_t and the ordinary "true stress" σ (the mean stress across the neck of the tensile specimen) is

$$\sigma_t/\sigma = 1/(1 + 2R/a) \log_e (1 + a/2R) \quad [1]$$

where R is the radius of curvature of the neck profile, and a the minimum radius of the neck cross section. In the range a/R up to nearly 1 and in the range of material strain up to slightly greater than 1 covered in these tests, Eq. [1] holds quantitatively for SAE 4140 steel and for annealed electrolytic copper. The curve of Bridgman's empirical relationship, showing the flow stress correction factor σ_t/σ versus the natural logarithmic strain ϵ_t was not in agreement with the tests on copper, although it was in quite close agreement with the tests on steel. Authors conclude that it would seem advisable to actually measure R in each test and determine σ_t/σ from Eq. [1] instead of using Bridgman's empirical relationship for σ_t/σ versus ϵ_t. It was found that the strain at fracture could be increased by increasing the neck profile radius and decreased by decreasing the profile radius. For both the steel and the copper tests the fracture conditions were best expressed by the maximum shear theory with a consideration of the effect of normal stress on the maximum shear plane.

In the copper-cutting experiments metal was removed by a process of shear, and essentially all of the strain in the process was concentrated along the plane extending from the tool point to the free surface. The values of effective stress σ_t and strain ϵ_t from the copper-cutting tests were compared with the true stress-strain and corrected stress-strain curves (corrected by the use of Eq. [1]) obtained from the tensile tests. All of the points obtained from the cutting tests were located above the corrected true stress-strain curve, and the points were located on either side of the uncorrected curve. The points obtained from the cutting tests corresponding to the least depth of cut were the farthest from the corrected true stress-strain curve, and it was stated that this result was to be expected in view of the increased flow stress at a given strain as the size of the specimen is decreased.

Authors have made an evaluation of Bridgman's equations based on experimental results. They point out that the good agreement between the experimental results and Eq. [1] does not necessarily constitute a verification of the method used by Bridgman to develop this equation. The strength criteria of fracture were tested over a rather limited range of principal stress ratios.

P. I. Wilterdink, USA

Failure, Mechanics of Solid State

(See also Revs. 2578, 2615, 2631)

2619. **Yokobori, T., Creep fracture of copper as nucleation process,** *J. phys. Soc. Japan* **7**, 1, 48–51, Jan./Feb. 1952.

Author reports creep-rupture tests of copper wire lasting for relatively short times and over relatively small ranges in stress and temperature (10 C to 29 C), a large number of specimens being tested. Results show linear relation between logarithm of stress and average time $\bar{t}$ to fracture at constant temperature; a similar relation is obtained between reciprocal of absolute temperature and log $\bar{t}$ at a given stress. Curves between time and probability of fracture are shown. Results are discussed from standpoint of nucleation theory (see following review). Author suggests further work is in order over a wider range of stress and temperature.

A. M. Wahl, USA

2620. **Yokobori, T., Failure and fracture of metals as nucleation processes,** *J. phys. Soc. Japan* **7**, 1, 44–47, Jan./Feb. 1952.

On the basis of nucleation theory and utilizing methods of statistical analysis, author derives rather complicated expressions for yield stress, ultimate strength, and fracture stress in metals as functions of absolute temperature and stress velocity. Assuming that deformation velocity is proportional to stress velocity, that the temperature range is not great, and that certain terms are less than unity, author shows that these more complicated expressions reduce to simpler formulas of the exponential type which show linear relations between logarithm of ultimate strength or yield stress and reciprocal of absolute temperature. Other subjects discussed from a similar viewpoint include: Effects of size on strength; transition temperature; frequency distribution of strength. Paper is rather difficult to read.

A. M. Wahl, USA

Material Test Techniques

(See also Revs. 2573, 2624, 2636, 2640)

2621. **Martin, E., Application of ultrasonic flaw detectors to the axles of railroad rolling stock** (in German), *Stahl u. Eisen* **72**, 4, 176–185, Feb. 1952.

Failures in axles start predominantly within the wheel seat or within the bearing section. The finding of such flaws is desirable before failure of the axle occurs. Ultrasonic flaw detectors made by Dr. J. H. Krautkrämer (similar to the Sperry reflectoscope) are being used successfully by the German railroads. Inspection is being made without removing the axles from the cars and locomotives.

Tests are being conducted using longitudinal waves as well as transversal waves. Depth of any flaw can be determined by a calibration chart when longitudinal waves are used and when the flaw is perpendicular to the surface. Transversal waves are applied to determine flaws in sections which are in the shadow of longitudinal waves; for example, flaws within the wheel seat. Transversal waves are transmitted into the axle under an oblique angle. Use of two crystals makes it possible to determine the depth of the flaw.

Robert O. Fehr, USA

2622. **Cabarat, R., Internal friction in small amplitude vibrations** (in French), *Mém. Soc. Ing. civ. Fr.* **104**, 5/6, 167–183, 1951.

Brief review is given of apparatus used by others for measuring damping of sound vibrations in metals. New test unit at Testing Laboratories of C.N.A.M. permits testing in partial vacuum (0.1 mm Hg) at temperatures up to 800 C.

Longitudinal sound waves are electrically generated in rod sample; electrostatic pickup measures amplitude. Internal friction in rod is measured in two ways: (a) By resonance curves over a range of frequencies; (b) by damping of free vibrations after generator is cut off. In (b), logarithmic recorder gives linear amplitude-time curve, slope of which indicates damping.

Some selected data illustrate applications of test. Phase changes with temperature in a Cu-Al alloy are followed in detail. Graphite in cast iron has little effect on friction when in nodular form, but increases friction markedly when in lanellar form.

Melvin Mooney, USA

2623. **Lightenberg, F. K., On a method for determining the moments in plates by means of a simple experiment** (in Dutch), *Ingenieur* **64**, 9, 0.42–0.50, Feb. 1952.

Author makes a reflecting model of the plate and photographs the image of a ruled screen, which this model reflects, in loaded as well as in unloaded state. If certain features are suitably chosen, the superposition of the two images shows the "moiré effect." Along each of these interference lines the first derivative of the deflection has a constant value. From these one can easily compute the second derivatives and, afterward, the mo-

ments. The necessary equipment and the process itself are relatively simple.

Author states the maximum deviation between experimental and real values amounts to 5% of the maximum moment.

M. Kuipers, Holland

Mechanical Properties of Specific Materials

(See also Revs. 2540, 2618, 2644)

2624. **Schwartzbart, H., Jones, M. H., and Brown, W. F., Jr., Observations on Baushinger effect in copper and brass,** *NACA Res. Memo.* E51D13, 37 pp., June 1951.

For any tensile prestrain between 0.905 and 0.65, the stress at 0.001 plastic strain in subsequent compression is about 0.7 of that at the same scalar strain for simple compression. The stress subsequently rises at a rate that is slower for a larger prestrain and levels off parallel to the compression curve at about 0.01 strain in compression. The subsequent compression stress-strain curve levels off parallel to and below the virgin compression curve by more and more as the prestrain increases.

For large tensile prestrains, there is appearance of a yield point in subsequent compression.

Stress-relief annealing caused the tension and compression curves following tensile prestrain and heating to approach each other in copper, indicating relief of residual stress, but both curves were raised in brass, probably due to strain aging.

Longitudinally prestretched material had different tensile curves in longitudinal and transverse directions. The difference was the same for isotropic and for cubically aligned sheet. This effect is related to the Bauschinger effect, according to previous work. Since the cubically aligned sheet presumably does not develop residual stresses between grains to nearly the same extent as isotropic material, then apparently the Bauschinger effect is not due to residual stresses caused by orientation differences between different grains.

J. D. Lubahn, USA

2625. **Clark, C. L., Fleischmann, M., and Freeman, J. W., Influence of extended time on creep and rupture strength of 16-25-6 alloy,** *Trans. Amer. Soc. Metals* **44,** 89–108, 1952.

Creep and rupture tests of an alloy having the nominal composition 16 Cr, 25 Ni, 6 Mo, balance Fe at 1200, 1300, and 1400 F for up to 12,000 hr showed that whereas tests of 2000-hr duration permitted a reasonable estimate of the stress to cause rupture in 100,000 hr, tests of 8000 hr were needed in some instances to attain the minimum or constant creep rate on which estimates of creep strength (stress to cause a specific rate of creep) are conventionally based.

Mechanical properties of the alloy in two conditions of heat treatment are given. Microstructural observations led to conclusion that strength of this alloy is, in part, attributable to a precipitation phenomenon.

George V. Smith, USA

2626. **Phillips, C. E., and Fenner, A. J., Some fatigue tests on aluminum-alloy and mild-steel sheet, with and without drilled holes,** *Instn. mech. Engrs. appl. Mech.* **165** (W.E.P. no. 165), 125–129, Proc. 1951.

Paper describes fatigue tests under fluctuating axial stresses using specimens with various sizes of central holes. Materials tested were an aluminum alloy and mild steel. Investigations were also made for different size panels. It was found that the larger specimens had the lower fatigue strength. It was also found that the specimens with the smaller holes influenced the fatigue strengths less than those with larger holes.

Joseph Marin, USA

2627. **Houwink, R., Elastomers and plastomers. Their chemistry, physics and technology. 1, General theory,** New York, Amsterdam, London, Brussels, Elsevier Publ. Co., Inc., 1950, xiv + 495 pp. $7.

Book consists of 10 chapters contributed by nine authors from four countries and covers economic aspects, chemistry, kinetics and mechanism of polyreactions, molecular constitution, mechanical properties, physics and structure, electrophysics, mechanical operations, polymer-liquid interaction, and plasticizers.

Only the chapter on mechanical properties by G. J. van Amerongen (59 pages) will be considered. It consists of an extensive discussion of second-order transition effects relative to mechanical behavior and the brittle point. The theory of plasticity is considered in the light of Newtonian flow and Eyring rate theory. The effect of orientation and cross-linking on the strength properties are described and illustrated for rubber. A theory of rubber elasticity is derived and applied to polymers. The viscoelastic phenomena are described in terms of the Maxwell and more complex mechanical models and are compared with various mechanical properties of polymers—especially rubbers. Chapter contains 167 references.

William N. Findley, USA

2628. **Schallamach, A., Elementary aspects of rubber abrasion,** *Engineering* **173,** 4490, 217–219, Feb. 1952.

Paper gives survey of work which has been done with the object of investigating the nature of rubber abrasion. First part reports the results of an abrasion experiment in which rubber was scratched with a needle. The aim of this research was to investigate the elementary mechanism of abrasion, such as may be expected to occur under the proud particles of an abrasive. Second part deals with the so-called "abrasion-pattern," a system of nearly parallel ridges which is found on abraded surfaces. In the third part, experimental evidence is given in support of the view that the outermost surface layer of a tire has the mechanical properties of an unloaded rubber, in spite of the fact that it contains reinforcing carbon-black which conveys considerable hardness to the bulk of the tire tread. Interpretation of this behavior is given in terms of the Mullins effect: Repeated deformations reduce the effective hardness of a reinforced sample until, finally, it is not much different from that of a pure gum.

From the author's summary by B. Gross, Brazil

2629. **Stiehler, R. D., Steel, M. N., and Mandel, J., Factors influencing the road wear of tyres,** *Engineering* **173,** 4490, 219–222, Feb. 1952.

Wear of tires in service is known to depend on numerous factors, such as position on vehicle and season. Paper gives results obtained with a test method suitable for evaluating these factors. Wear is determined by periodic measurements of weight of tire. Tests are designed round a 4 × 4 Latin square, permitting the simultaneous testing of 16 tires of four vehicles; they were divided into seasons of 3 months each. Main results are: (a) Wheel position. While variations between different vehicles are small, for trucks the rate of wear on rear positions is four times that on front positions, probably due to loading. Differences are smaller for passenger cars. (b) Daily and seasonal variations. Results, though somewhat complex, suggest correlation between amount of sunshine and rate of wear. (c) Type of rubber black. No "interaction" between the rubbers and the blacks was found. Thus, they are mutually independent in their effects on tread wear.

B. Gross, Brazil

2630. **Soden, A. L., A practical manual of rubber hardness testing,** London, Maclaren & Sons, 49 pp. 3s. 6d.

This manual covers practical hardness-testing of soft vulcan-

ized rubbers, dealing with standard hardness tests and the design, calibration, and use of the instruments now in use. Results of the simple theory of hardness-testing are given briefly, showing the approximate relationship with the elastic constants. Conversion tables for the various scales of hardness are appended, but it is made clear that the results obtained depend on the instrument and on the operator. The manual gives an exhaustive coverage of the practical aspects of this field.

Donald G. Ivey, Canada

2631. **Bartenev, G. M., On certain rules of fracture strength of rubber** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **82**, 1, 49–52, Jan. 1952.

Tensile strength of vulcanized Buna S rubber, without carbon black, was measured on 100 or more specimens for each of three thicknesses. Mean strength increases from 21 to 38 kg/cm² with decrease of thickness from 2.2 to 0.4 mm; coefficient of variation increases from 0.13 to 0.19; distribution is approximately normal. Addition of carbon black produces a skew distribution, with mode at 125 kg/cm² and tail at low strengths. As rate of stretching increases from 10^{-5} to 1 sec $^{-1}$, strength more than doubles; log-log plot is linear. Author stresses limitations of standard tests as index of practical performance.

William Fuller Brown, Jr., USA

2632. **Andrade, E. N. da C., and Henderson, C., The mechanical behaviour of single crystals of certain face-centred cubic metals,** *Phil. Trans. roy. Soc. Lond. (A)* **244**, 880, 177–203, Dec. 1951.

Single crystals of gold, silver, and nickel have been prepared and examined in bending to the point of fracture. Strain hardening is found to increase with increased temperature at low temperatures, but to decrease with increased temperature at high temperatures. Surface contamination of silver is purported responsible for abnormal results observed for silver. Results are discussed in terms of dislocation theory. Asterism of x-ray photographs is correlated with hardening properties of metals tested. The following empirical relation between breaking stress σ_f of single crystals and temperature T is suggested: $\sigma_f^{1/3} = a(T/T_m) + b$, where a and b are constants, and T_m is absolute melting temperature of metal.

Milton C. Shaw, USA

2633. **Schneider, W. H., On yarn breakages and spinning limits in worsted spinning** (in German), Thesis 1837, ETH Zürich, 29 pp., 1951.

After an introduction showing the interest of the subject for the worsted spinning industry, the questions posed in chapter II—why and how much should be doubled—are answered by treating an example, the results of which agree with those deduced from the statistical theory.

In chapters III and IV it is shown that the irregularity in a yarn, caused by the random disposition of the fibers—in accordance with the theory of Martindale based on the assumption of a Poisson distribution—corresponds to a cyclic irregularity with a mean period of twice the mean length of the fibers.

A recurrent method giving an easy way for calculating the frequencies and the probabilities of Poisson's distribution is developed, and a table giving these values for a number of fibers from 0 to 64, a mean number of 44 being supposed, is produced.

The method of calculating the frequency of the yarn breakages (number of breakages per 100 spindle-hours) is deduced in chapter V from the preceding results. In chapter VI the irregularity of a yarn is deduced from the diagrams given by the Uster apparatus, and the "irregularity factor" is calculated by comparison with the theoretical irregularity.

Some interesting results are given in chapter VII; the tenacity of a worsted yarn was found independent of the test time (between 2 and 15 sec); high correlation coefficient (0.81) was found between the tenacity of yarn and the number of fibers in the smallest section of tested portion, etc. Results of tests made on a Ringframe with merino worsted (Nm 58, 48, and 40) concerning yarn breakages and yarn tension are given in chapter VIII, and the obtained results are compared with the calculated ones.

Author concludes that the irregularity factor has to be taken low at the different machines to diminish yarn breakages, and that by increasing the number of fibers in cross section—for instance, by mixing 1.5 denier rayon with wool of 4.43 denier—the number of breakages can be considerably reduced.

D. De Meulemeester, Belgium

2634. **Emery, E. M., and Flanigan, A. E., Relation of notch strain to deflection in the notch-bend test,** *Weld. Res. Suppl.* **16**, 12, 607s–612s, Dec. 1951.

A method is presented for measuring the strains at the base of a $^1/_{16}$-in. radius U-shaped notch in a longitudinally welded bend specimen. The strain was determined by the change in spacing of scribed lines originally set 0.020 in. apart in the base of the notch. The relation between notch strain and specimen deflection was determined by periodically interrupting bending to measure the strain. The relationship was found to be approximately linear and dependent upon not only the presence of the weld crown, a geometrical influence, but also on the presence of the weld itself, a metallurgical factor. This was taken as indicating the existence of a "metallurgical notch."

Reviewer's note: For additional information on the extreme anisotropy caused by welds, see Hartbower and Pellini [AMR **4**, Rev. 2048].

C. E. Hartbower, USA

2635. **Artman, R. A., and Thompson, D. O., Elastic constants of beta-brass single crystals,** *J. appl. Phys.* **23**, 4, 470–474, Apr. 1952.

Authors give results of measurements of elastic constants of single crystals of beta-brass of various compositions. The constants were determined from dynamical experiments, using the composite piezoelectric oscillator method, and from statical experiments in which the torsion and flexure of the specimen, when subjected to axial torque, were measured by a mirror method.

The composition of the specimens, expressed as the ratio of the atomic concentration of copper to that of zinc, varied between the limits 1.08 and 1.20, and, over this restricted range, it was found that the reciprocal of the values of Young's modulus and the rigidity modulus varied linearly with concentration.

R. M. Davies, Wales

2636. **Eyring, H., Alder, M. G., Rossmassler, S. A., and Christensen, C. J., Forced vibrations of polyamide monofils,** *Text. Res. J.* **22**, 4, 223–246, Apr. 1952.

The behavior of materials when subjected to repeated stresses is important from the standpoint of practical rheological behavior and its correlation with molecular structure. An apparatus is described for measuring the response of alternating tensile forces or strains on monofilaments. The energy absorbed by the filament is calculated from a hysteresis loop.

Data are given on duPont Nylons 66, 610, and 2-Me-66 over a frequency and temperature range. A theory based on the Eyring absolute reaction-rate treatment is given in an attempt to explain the results. Samples must be subjected to a number of cycles before the properties reach a steady-state value. The energy absorbed per cycle by the materials was nearly independent of the frequency, but dependent upon the temperature.

Lawrence Nielsen, USA

2637. Stanworth, J. E., Physical properties of glass, New York, London: Oxford Univ. Press, 1950, viii + 224 pp. $4.25.

This is one of several excellent monographs on physical properties of glass which have been published in the last five years. It is well written and complete (early 1949). It is not, as its name might imply, a tabulation of physical properties of inorganic glasses. Rather it is an excellent attempt to present and correlate the theoretical and experimental work concerning the structure of glasses. Reviewer believes the research worker will find the book invaluable as a source book not only of work done in the past, but, more important, of points to be investigated in the future.

Book is divided into three principal divisions: 1—Structure of (solid) glasses, based primarily on the work of Warren and coworkers; 2—Properties of solid glasses, correlating results whenever possible with section 1; and 3—Properties of liquid glasses, wherein correlation with structure is seldom possible and advantage is often taken of empirical formulas and structure-insensitive theories such as reaction kinetics. D. A. Stuart, USA

2638. Adam, H., Theoretical foundations of pressure glass sealing and its practical consequences (in German), *Feinwerktech.* **56**, 2, 29–40, Feb. 1952.

General basic equations within validity range of Hooke's law are deduced for an n-component system of concentrical rings or cylinders with different elastic and thermal properties. Obtained equations are applied to some of the technically useful glass-metal seals to show how the theory works. Author shows that it is practically necessary to avoid tension stresses in the glass. The first case is a 3-component seal with glass ring between a metal core and an outer metal ring. The thermal properties of the core are adapted to those of the glass. The second case is still a 3-component seal, but the properties of the core are not adapted. In none of the cases is the relaxation effect of glass under stress considered. Ragnar Nilson, Sweden

2639. Rieppel, P. J., and Voldrich, C. B., Fracture initiation and propagation in welded ship steels, *Weld. J.* **31**, 4, 188s–197s, Apr. 1952.

Two hull-grade steels were used to study propagation of fracture in welded and prime plate specimens by Kinzel test. Electrodes used were of E6010 class. Results show that deflections, at which cracks of 0.005 in. deep appear, are five times larger in the unwelded specimens than in the welded ones.

Energy to cracking in welded specimens is less than 14% of energy to cracking of prime plate specimens. Tests are run at temperatures on both sides of transition temperature. Authors conclude that more attention should be given to properties of weld metal. W. Soete, Belgium

2640. Smith, W. K., Woolsey, C. C., Jr., and Wetmore, W. O., Effect of high heating rate on some elevated temperature tensile properties of metals, *Trans. Amer. Soc. Metals* **44**, 689–704, 1952.

A method and equipment were developed for determining tensile properties of metals when subjected to a constant load and heated at rates exceeding 100 F per sec until rupture. Stresses up to the ambient temperature yield strength and heating rates up to 3500 F (1930 C) per sec were investigated. Test data are presented for AISI C 1020 and SAE 4130 steels and for 14S-T6, 24S-T4, and 75S-T6 aluminum alloys. These data indicate that design stresses higher than those given by standard short-time high-temperature data may be used where a part must withstand a stress for a short time while its temperature is rapidly increasing. They also indicate that the improvement in tensile properties of steel caused by either work-hardening or heat treatment could be utilized under these conditions of loading and heating.

From authors' summary by W. T. Lankford, Jr., USA

2641. Pesante, M., Determination of the cooling capacity of quenching baths (in Italian), *Metallurgia ital.* **44**, 4, 145–152, Apr. 1952.

Article describes a new type of instrument for the determination of the cooling capacity of quenching baths. By means of a proper electronic equipment, the cooling rate curve (in °C/sec) vs. the temperature (in °C) can be traced with this instrument.

The curve thus obtained univocally characterizes the cooling properties of the bath. Results of preliminary tests are reported over different types of quenching baths (water and aqueous solutions, oils, salt baths, metal baths, etc.).

From author's summary

2642. Magnel, G., Precompressed steelwork (in French), *Publ. int. Assn. Bridge struct. Engng.* **11**, 325–336, 1951.

In the first of two parts, author shows that a tie rod (e.g., for a parabolic roof) can be made from precompressed steel with a great saving both in weight and cost, without decreasing in any way the factor of safety and by only increasing its deformation in a reasonable way. In the second part, he compares classical beams to precompressed beams in the case of an airplane hangar covered by a flat roof, supported by beams of 102-m span and 250 m apart.

The saving in weight by the use of precompression is 26%; the saving in cost 18% without any decrease in the factor of safety and with only an admissible increase in deflection.

From author's summary

Mechanics of Forming and Cutting

2643. Kienzle, O., Determination of forces and power of tools and machine tools (in German), *ZVDI* **94**, 11/12, 299–305, Apr. 1952.

Analysis of tool forces when turning different materials at various cutting speeds, feeds, and depth of cut. Data and nomographs are arranged for machine-tool designers and users in regard to power requirements and tool life of HSS tools and carbides. Cutting forces for broaching are also determined.

A. O. Schmidt, USA

2644. Colwell, L. V., Holmes, H. J., and Rote, F. B., A comparison of parameters for the machining of gray cast iron, Ann. Meeting ASME, Atlantic City, Nov. 1951. Pap. no. 51—A-47, 9 pp. = *Trans. ASME* **74**, 6, 1029–1037, Aug. 1952.

The investigation reported had as its purpose the determination of suitable physical or metallurgical factors which can be used for predicting machinability for cast irons. The machinability was taken as the surface speed for 20-minute tool life and was determined from tool-life tests on a lathe. The 11 cast irons investigated, varying in microstructure and physical properties, were subjected to various tests with the following results: Combined carbon, microhardness, and nucleation or graphitization tendency were found to be the most suitable variables for correlating with machinability as defined above. Brinell hardness, tensile strength, drilling forces, and milling power showed poor correlation.

The investigators have provided useful information which should find practical application, but they warn that the results are preliminary in nature and that application should not be attempted without further investigation.

Erich G. Thomsen, USA

2645. **Hornung, A., Chip formation in grinding** (in German), *Acta Techn. Hung., Budapest* **1**, 3, 241–259, 1951.

In this geometrical treatment of the process of grinding, the latter is considered as a milling process. If both the grinding stone (diameter d) and the piece of work (diameter D) are cylindrical, a formula is derived for the average thickness of the chip, namely, $f^{1/2}t\,(v_1/v_2)\,(D \pm d)^{1/2}\,d^{-1/2}D^{-1/2}$, where f is depth of cut (overlap of d and D, feed), t spacing of corns of grinding stone, v_1/v_2 ratio of circumferential velocities of workpiece and stone; the plus sign to be used in the case of exterior grinding, the minus sign in the case of interior grinding.

C. Zwikker, Holland

2646. **Trent, E. M., Some factors affecting wear on cemented carbide tools,** *Instn. mech. Engrs. Proc. (A)* **166**, 1, 64–70, 1952.

See AMR **5**, Rev. 2393.

Hydraulics; Cavitation; Transport

(See also Revs. 2616, 2658)

2647. **Bouvard, M., The influence of turbulence on the fall velocity of solid particles in water** (in French), *Houille blanche* **6**, 6, 862–864, Nov./Dec. 1951.

On the hypotheses that (a) the velocity fluctuation due to turbulence is constant at a particular depth of flow and has the values $\pm\, v$ (excluding intermediate values), and (b) the resistance of a falling solid particle is proportional to the fall-velocity squared, the expression for the mean resistance on the particle is easily found, as a function of v and the fall velocity V (supposed uniform). Comparing this resistance with that encountered in calm water, the ratio V/V_0 is calculated (V_0 = fall velocity in calm water), which always results in a value less than unity.

D. Citrini, Italy

2648. **Gherardelli, L., A remark on the equation of surge tanks** (in Italian), *Energia elett.* **29**, 4, 221–223, Apr. 1952.

Paper deals with friction term in equation of unsteady flow in closed conduits. Flow resistance is proposed to be represented by an analytic and odd function of velocity, determined by author under condition of approximating proportionality to first power for very small values of velocity, and to second power for large ones.

Giuseppe Evangelisti, Italy

2649. **Stringer, J. E. C., Hydraulic lock: another explanation,** *Engineering* **173**, 4500, 509–511, Apr. 1952.

Article describes a series of experiments made with a felt filter of high filtering efficiency, using which no lock could be observed. The piston valve in the present experiments was ball-guided centrally in its body, with a clearance all round its periphery, so that eccentric locking of the type described by Dr. Sweeney [AMR **5**, Rev. 2077] could not occur. Lock was only observed when the felt filter was removed from the supply line.

From author's summary

2650. **Cunningham, R. G., Super-critical compressible flow through a square-edged orifice,** Proc. Midwest. Conf. Fluid Dynamics, 1st Conf., May 1950; J. W. Edwards, Ann Arbor, Mich. 373–388, 1951. $10.

Based on the one-dimensional isentropic flow relations, an equation is derived that gives the ratio of the minimum cross-sectional area of a jet downstream of an orifice to the area of the orifice for pressure ratios below the critical value. The force exerted by the fluid on the orifice plate, in the direction of flow, is assumed to be the same as that for incompressible flow having the same flow rate. At the critical pressure ratio, the equation reduces to that of Buckingham, which is derived for the sub-critical range.

The jet contraction ratios computed from the experimental data obtained by Bachmann on air flow and by Schiller on superheated steam agree with the theoretical values within about 1% for pressure ratios down to about 0.3.

Chung-Hua Wu, USA

2651. **Valken, K., A graphic method for determination of backwater curves in stationary flows in open water courses** (in Dutch), *Ingenieur* **64**, 16, B.36–B.39, Apr. 1952.

In title source no. 23, 1951 [AMR **4**, Rev. 3917], a graphic method has been developed by which all types of backwater curves can be determined for gradually varied flows in open watercourses. Thereby, the influence of the velocity head can be taken into account if necessary. Although it is possible to use the method for nonuniform channels, another construction has been described which lends itself pre-eminently for watercourses with greatly varying successive sections. In that case, however, the influence of the velocity head has to be neglected.

The graphic method discussed in this paper is considered to be a completion of the two mentioned above. Applications can be found especially in those cases where the successive sections vary greatly. The basic publication can be found in *Houille blanche* no. 3, 1950 [AMR **4**, Rev 1621]. This paper presents a number of useful additions as to the normal and critical depth, and, furthermore, a description is given how to use the method when sluices, weirs, bridges, etc., form a part of the watercourse, or when losses of energy due to decrease of velocity of the presence of bends in rivers may not be disregarded.

From author's summary by R. Timman, Holland

2652. **Biésel, F., and Suquet, F., Laboratory wave-generating apparatus** (in French), *Houille blanche* **6**, 4, 5: 475–496, 723–737; July/Aug., Sept./Oct. 1951.

This continuation and conclusion of an article, the first part of which was reviewed in AMR **4**, Rev. 4501, presents sixteen different types of wave-generating apparatus used in various laboratories of Europe and America, stating for each the principle of operation, the possibility of computing the amplitude of the wave produced, the reflecting capacity, and other characteristics. Article is remarkably complete and well illustrated.

André Leclerc, Canada

Incompressible Flow: Laminar; Viscous

(See also Revs. 2651, 2686, 2694, 2730)

2653. **Taylor, Sir Geoffrey, The action of waving cylindrical tails in propelling microscopic organisms,** *Proc. roy. Soc. Lond. (A)* **211**, 1105, 225–239, Feb. 1952.

The action of the tail of a spermatozoon is discussed from the hydrodynamical point of view. The tail is assumed to be a cylinder which is distorted by waves of lateral displacement propagated along its length. The resulting stress and motion in the surrounding fluid are analyzed mathematically. Waves propagated backward along the tail give rise to a forward motion with velocity proportional to the square of the ratio of the amplitude of the waves to their length. The rate at which energy must be supplied to maintain the waves against the reaction of the surrounding fluid is calculated.

Similar calculations for the case when waves of lateral displacement are propagated as spirals show that the body is propelled at twice the speed given it by waves of the same amplitude when

the motion is confined to an axial plane. An externally applied torque is necessary to prevent the reaction of the fluid due to spiral waves from causing the cylinder to rotate. This is remarkable because the cylinder itself does not rotate.

A working model of a spermatozoon was made in which spiral waves could travel down a thin rubber tube without rotating it. The torque just referred to was observed and was balanced by an eccentric weight. The calculated speed of the model was higher than was observed, but this discrepancy could be accounted for by the fact that the model has a body containing the motive power while the calculations refer to a disembodied tail.

From author's summary by L. J. Tison, Belgium

2654. Mohr, E., Acceleration resistance of moving bodies in liquids (in German), *ZAMM* **32**, 2/3, 87-88, Feb./Mar. 1952.

A simplified proof is given of S. Neumark's theorem following which the resistance W experienced by a fixed body in a linearly accelerated ideal fluid can be calculated from $W = W' + M\, du/dt$. Here W' denotes the resistance of the body moving with the accelerated speed u; M is the mass of the fluid displaced by the body. This result can be generalized, but it does not hold for rotations of the body. Georg P. Weinblum, Germany

2655. Morgan, G. W., On the steady laminar flow of a viscous incompressible fluid in an elastic tube, *Bull. math. Biophys.* **14**, 1, 19-26, Mar. 1952.

In the problem of the viscous flow through a rigid walled tube, the axial velocity distribution, when the radial velocity component is zero, follows the Poiseuille law. Author investigates the flow under similar conditions through an elastic tube whose diameter decreases in the direction of motion due to the axial pressure gradient.

Approximate solutions are developed, and the change in the radius of the tube is determined as a function of the rate of mass flow. The solutions are shown to be better approximations than those given by Rashevsky [title source, **7**, 35-39, 1945].

G. M. Lilley, England

2656. Meyer, R., The ellipsoidal schematization of a particle falling into water (in French), *Houille blanche* **7**, 1, 52-54, Jan./Feb. 1952.

Author concludes by kinematical plausibility arguments that various shaped bodies can fall with rotation in Stokes' flow (Stokes' linearization of viscous equations, uniform velocity, and angular velocity at infinity). Author apparently is unaware Stokes' flow may not exist, e.g., it is well known that none exists about a circular cylinder. In particular, his cylindrical example is vitiated by nonexistence shown in a report by reviewer and M. Krakowski for general cylindrical shapes. Thus, although more plausible there, reviewer cannot accept author's three-dimensional source-sink "construction" as proof of anything, either.

A. Charnes, USA

2657. Gerbes, W., On unsteady, laminar flow of an incompressible viscous fluid in cylindrical pipes (in German), *Z. angew. Phys.* **3**, 7, 267-271, July 1951.

Author studies, by means of Laplace transforms, the initial value problem of the flow in a long pipe when a pressure difference is suddenly applied between two sections of the pipe. Three particular cases are treated: (a) Fluid is initially at rest and a constant pressure difference is suddenly applied; (b) the initial state is steady Poiseuille flow and the pressure difference which is required to maintain this flow is suddenly removed; (c) fluid is initially at rest and a pressure difference in the form of a trigonometric function of the time is suddenly applied. In all cases it is assumed that only the axial velocity component is different from zero. Curves of typical velocity profiles are given.

George W. Morgan, USA

2658. McClain, C., Fluid flow in pipes, New York, Industrial Press, 1952, 123 pp. $3.

Purpose of book is to acquaint technicians with general theory of flow in pipes. Author discusses laminar and turbulent flow completely, and clearly shows manner in which friction factor is a function of Reynolds number and relative roughness only. Method of analysis for simple piping systems is also given.

In presentation of material, dimensional homogeneity is stressed, and dimensions of flow and fluid properties are given in all commonly used systems. In particular, viscosity is explained, and conversion equations for various unit systems are given. In fact, so many equations are given relating the various systems that it will be somewhat confusing to students. Calculus is not essential in understanding the material. Book should thus be easily understood by technicians.

Reviewer has several general criticisms: Language is loose in many places and terms unfamiliar to fluid mechanics are used; e.g., on page 61, it is stated that the terms laminar and viscous are synonymous. This, of course, is not strictly true, since turbulent flows are inherently viscous. As a further example, the term "design practice" is used to head a chapter wherein Bernoulli's theorem and the form resistance of pipe fittings are discussed. In examples of the solution of pipe-flow problems, only the most elementary cases are treated, i.e., it is clearly shown how to solve for the head loss using the Moody diagram—a direct solution. No indication is given of the method used when discharge or pipe diameter are unknown. For these problems either diagrams similar to the Moody diagram with different ordinates or an example of the use of successive approximations should have been included.

W. D. Baines, Canada

Compressible Flow, Gas Dynamics

(See also Revs. 2684, 2696, 2699)

2659. Kaplan, C., On the particular integrals of the Prandtl-Busemann iteration equations for the flow of a compressible fluid, *NACA Rep.* 1039, 6 pp., 1951.

See AMR **4**, Rev. 1673.

2660. Kofink, W., On the theory of three-shock configurations (in German), *Ann. Phys., Leipzig* (6) **9, 10,** 2/4, 3: 200-212, 200; 1951, 1952.

Three-shock configurations are here represented by an equation of the sixth degree. Certain special and degenerate cases in which the order of the equation may be reduced are considered in analytical detail. The second paper corrects a misprint in the first.

D. C. Pack, Scotland

2661. von Mises, R., On some fundamental problems of hydrodynamics (in German), *Öst. Ing.-Arch.* **6**, 2, 77-85, Jan. 1952.

Author studies the possible discontinuities appearing in the solutions of the hydrodynamic equations whereby the usual adiabatic condition is replaced by a much more general relation. The principal results are as follows: (1) In the case of a fluid without viscosity and heat conduction, the theory of characteristics leads to two different types of discontinuities, (a) those which are found in the jet problem of Helmholtz, in the wing theory of Lanchester-Prandtl, and in the so-called contact dis-

continuities of compressible fluids; (b) those discontinuities which are well known from the theory of potential flow at supersonic velocities. (2) In the presence of viscosity and/or heat conduction, the theory of characteristics admits only discontinuities of type (a). In this case, however, one can find asymptotic integrals (in a similar way as in the theory of boundary layers) for Reynolds number and/or Prandtl number tending to infinity. These asymptotic integrals represent the flow patterns that are usually called shocks.

From author's summary by S. Tomotika, Japan

2662. **Hawthorne, W. R., Weddell, D. S., and Hottel, H. C., Mixing and combustion in turbulent gas jets,** Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 266–288, 1949. $13.50.

The theory of turbulent jets is applied to diffusion flames. Equations are derived for the concentration profiles and visible flame length. These are given as functions of the fuel and oxidizer properties but are found to be independent of Reynolds number. Theory is compared with experiments on combustion of several gases issuing from rounded, channel, and orifice nozzles. Some results on an industrial-type burner are also reported.

Paper is an extension to turbulent flow of work of Hottel and Hawthorne [title source, pp. 254–266] on laminar flames. Results appear consistent with those of Wohl, Gazley, and Kapp [ibid., pp. 288–300]. William Squire, USA

2663. **Miles, J. W., On virtual mass and transient motion in subsonic compressible flow,** *Quart. J. Mech. appl. Math.* **4**, part 4, 388–400, Dec. 1951.

Subsonic transient motion of a compressible fluid past a circular cylinder is treated on the basis of acoustic approximation and with the aid of Laplace transformation. The concept of virtual mass is shown to be of no use in computing impulsive motion. The work required to generate the impulsive motion is not entirely recoverable. This radiation loss is calculated and is seen to be of little importance except in the case of large bodies undergoing initial accelerations. G. V. R. Rao, USA

2664. **Loewner, C., A transformation theory of the partial differential equations of gas dynamics,** *NACA TN* 2065, 56 pp., Apr. 1950.

In first part, assuming continuous second derivatives, author finds the most general linear homogeneous transformation of Baecklund type which transforms a given equation $\zeta_s' = H\zeta_t'$ into an equation of the same form with same independent variables. In this and the following, ζ and ζ' denote column vectors, capital letters square matrixes, and subscripts differentiation. Result is

$$\begin{aligned} \zeta_s' &= W\zeta_s + HB\zeta + HD\zeta' \\ \zeta_t' &= W\zeta_t + B\zeta + D\zeta' \end{aligned} \qquad [B]$$

together with a system of first-order differential equations connecting H, B, D, and W. (Reviewer's note: Preceding is discussed in paper only for vectors with two components, but derivation given is seen to hold for real or complex vectors with any finite number of components.)

Results are applied to steady irrotational plane flow of a nonviscous fluid, identifying the components of ζ with potential φ and stream function ψ, respectively. Families of speed-density relations depending on up to five parameters are found, for which the equations satisfied by φ and ψ in the hodograph plane can be transformed to the Cauchy-Riemann equations, to the equations corresponding to the wave equation, or to those corresponding to the Tricomi equation. Each family is defined by a single differential equation of Riccati type. Transformation consists in each case of a change of independent variables followed by a transformation [B], coefficients of the Baecklund transformation being elementary functions depending on s alone.

Transformations [B] do not form a group, making it possible to use results of first part of paper to construct families of the preceding type with arbitrarily many parameters.

The possibility of finding suitable approximate speed-density relations from the families obtained is discussed in the case of the pressure-density relation $p = a\rho^\gamma + b$. It is shown that the speed-density relation corresponding to $\gamma = -1$, $a < 0$ is included. Examples of approximate relations are given, suitable for subsonic and transonic flows, respectively, with numerical calculations to estimate ranges of validity for ordinary values of γ. Andrew Van Tuyl, USA

2665. **Kahane, A., and Lees, L., Unsteady one-dimensional flows with heat addition or entropy gradients,** Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 222–229, 1949. $13.50.

See AMR **2**, Rev. 218.

2666. **Flax, A. H., Reverse flow and variational theorems for lifting surfaces in nonstationary compressible flow,** *Cornell aero Lab. CAL* 42, 21 pp., Feb. 1952.

A reverse-flow theorem for compressible flow with simple harmonic time dependence is derived, valid within the limitations of linearized theory. This theorem gives a relationship between solutions for lifting surfaces of given planform in direct and reverse flow. Its extension to arbitrary unsteady flows is obvious for cases that can be treated by Fourier's integral. The reverse-flow theorem is applied to the determination of relations between aerodynamic coefficients in opposite flows, including the extension to oscillatory motion of certain known results about lift, pitching moment, and rolling moment. Also obtained are influence functions by which total lift, pitching, and rolling moments for arbitrary wing oscillations and deformations can be computed in terms of pressure distributions for simpler types of motion in reverse flow.

Based on the same considerations that are used to establish the theorem, an adjoint variational principle is derived. Author asserts its probable usefulness in finding approximate solutions to unsteady lifting-surface problems, but applications are deferred to a later paper. Holt Ashley, USA

2667. **Graham, E. W., and Graham, M. E., Energy, virtual mass and wave drag for compressible flows,** *Douglas Aircr. Co. Rep.* SM-14211, 11 pp., Nov. 1951.

By considering the kinetic and compression energies of the fluid through which a body has accelerated slowly from rest, an expression for the total energy required to create a compressible flow pattern is derived, assuming small density perturbations. This energy is then used to calculate the wave drag of a two-dimensional airfoil moving with constant supersonic velocity, the result being in agreement with linearized theory.

A. R. Mitchell, Scotland

2668. **Bergman, S., Operator method in gas dynamics** (in German), *ZAMM* **32**, 2/3, 33–45, Feb./Mar. 1952.

This expository paper is a very original approach to subsonic compressible-flow problems using the hodograph method. In analogy to incompressible flow which is intimately connected with the Laplace equation and analytic functions, the author discusses two integral operators which transform the class of analytic func-

tions to solutions of the elliptic partial differential equation. These solutions are stream functions of subsonic flows of ideal gases around arbitrarily shaped profiles. If the coefficients of the equations are entire functions, results of classical function theory can be extended, with the aid of the "integral operator of the first kind," to solutions of the more general elliptic equation. When the coefficients are singular, and this is the form which has application to compressible flow, the "integral operator of the second kind" gives a generalization of known theorems of hypergeometric functions, and with suitable modifications reduces to classical Fuchsian theory.

An extension of the method to the mixed case is noted. There is an excellent bibliography of author's work for over the past decade on these problems. Robert Simon, USA

2669. Young, G. B. W., and Janssen, E., The compressible boundary layer, *J. aero. Sci.* **19**, 4, 229–236, 288, Apr. 1952.

Differential analyzer has been used to obtain solutions of laminar boundary-layer equations with zero axial pressure gradient, constant wall temperature, and with the variation of gas properties (viscosity, conductivity, specific heat) given by most accurate experimental and theoretical data. Skin friction, heat transfer, film temperature, recovery factor and various boundary-layer thicknesses are presented for high Mach numbers and for three potential flow static temperatures.

Reviewer comments that because of extreme brevity and lack of definitions of terms and symbols, only a boundary-layer specialist will find paper useful. It may be further pointed out that the case of zero axial pressure gradient does not correspond to the flow over a flat plate at the usual aeronautical Reynolds numbers and at the high Mach numbers contained in the report. Actual surface would have to be concave in order for the pressure to be constant. Paul A. Libby, USA

2670. Hermann, R., Diffuser efficiency of free jet supersonic wind tunnels at variable test chamber pressure, *Fairchild Publ. Fund. Inst. aero. Sci. Prepr.* 349, 21 pp., 8 figs., 1952.

The flow process in the diffuser of a supersonic wind tunnel with free jet is investigated. General case of test-chamber pressure unequal to the nozzle axial pressure is considered. Using basic equations of continuity, energy, and momentum flow through a control surface, an exact solution for one-dimensional, nonviscous, steady flow is obtained. Even though the unequal pressures may not be used for model testing, the results of this analysis are important in the design and operation of such tunnels. The "slow-starting" process of this type tunnel is quantitatively investigated.

G. V. R. Rao, USA

2671. Hicks, B. L., Aerodynamical effects of heat released by combustion of steadily flowing gases, Third Symp. Combust. Flame Expl. Phenom.: Baltimore, Md., Williams & Wilkins, 212–222, 1949. $13.50.

Paper considers the steady flow of an inviscid, nonheat-conducting compressible fluid with heat addition. First, the fundamental equations of inviscid compressible fluid with heat sources are recalled; then several simple explicit solutions of these equations are discussed.

A simple radial flow is first investigated in detail. It shows that flow without limit circles can be constructed by adding heat. Similar results are indicated for vortex flow. Next, the irrotational uniplanar diabatic flows are treated. Finally, the perturbation of almost uniform flow by a local source of heat is treated. The fundamental equations are linearized. The effects of heat sources distributed in an arbitrary fashion throughout the flow field could be built up by superposition of the elementary solutions. S. I. Pai, USA

2672. Henderson, A., Jr., Pitching-moment derivatives C_{m_q} and $C_{m_{\dot\alpha}}$ at supersonic speeds for a slender-delta-wing and slender-body combination and approximate solutions for broad-delta-wing and slender-body combinations, *NACA TN* 2553, 29 pp., Dec. 1951.

Author applies the method of Munk and R. T. Jones to the calculation of the pitching moment derivatives C_{m_q} and $C_{m_{\dot\alpha}}$ for a slender-wing body combination at supersonic speeds. The wing is of triangular shape and is attached to the body ahead of the trailing edge (no afterbody). It is suggested that a simple correction factor may be applied to obtain approximate solutions for larger aspect ratios. This procedure, which is of an empirical nature, is based on the consideration of a delta wing without body. It is shown that it leads to satisfactory results for the case of a conical body and, hence, is considered applicable to more general cases. A. Robinson, Canada

2673. Berndt, S. B., Note on the position of the aerodynamic center of pointed wings at subsonic speeds, *Roy. Inst. Technol., Div. Aero., Stockholm, KTH-AERO TN* 5, 6 pp., 1949.

2674. Picard, Cl., and Chevallier, J. P., Measurement of pressure and forces on a rectangular half-wing in supersonic flow (in French), *Rech. aéro.* no. 26, 3–12, Mar./Apr. 1952.

Pressure distribution at four spanwise locations (13 holes each) were measured simultaneously with pitching moment and hinge moment (35° full span aileron) on a rectangular half-wing—aspect ratio 2, 7.5% thick biconvex section—at Mach 2. Comparison with linear theory shows latter predicts local forces very well for incidences up to 6° (except near trailing edge), and predicts over-all effects, lift in particular, quite well up to 10°. Results show frontward displacement of center of pressure, reduced aileron effectiveness, and increased nose-flap effectiveness over theoretical predictions. J. S. Isenberg, USA

2675. Friedman, D., and Westphal, W. R., Experimental investigation of a 90° cascade diffusing bend with an area ratio of 1.45:1 and with several inlet boundary layers, *NACA TN* 2668, 30 pp., Apr. 1952.

Tests on this bend with a 19 × 19-in. inlet were conducted at Mach numbers up to 0.41 and Reynolds numbers (based on airfoil chord of 4 in.) up to 9.5×10^5. Five inlet boundary-layer thicknesses and shape parameters were also used, which ranged from $^1/_4$ in. and 1.22 to $6^1/_2$ in. and 1.67, respectively. For the thick boundary-layer runs, it was found that the diffusing bend losses were equal to the losses of a vaned 90° bend with no diffusion. The total pressure-loss coefficient varied from 0.11 to 0.24 for the thickest boundary layer. The contribution from the cascades to this loss is small. The losses increased slightly with M and R_e. The performance of a circular diffuser with an optimum expansion angle followed by a vaned bend is superior. The diffusing bend, however, is much shorter, and in certain applications may be advantageous.

Irvine I. Glass, Canada

2676. Ericksen, J. L., On the uniqueness of gas flows, *J. Math. Phys.* **31**, 1, 63–68, Apr. 1952.

Let v, c, γ be the fluid speed, sound speed, and the adiabatic exponent, respectively, of a plane, stationary adiabatic, ideal gas flow. Such a flow is called unique if, for any other flow with the same streamlines, the corresponding quantities are Av, Ac, γ where A is a constant.

Author proves two theorems: (1) If a flow is not unique, then either $V = v(\varphi)$ or $v = v(\psi)$, where φ and ψ are the velocity potential and stream function. (2) A flow which is not unique must be either of the vortex type or the source-sink type.

L. M. Milne-Thomson, England

2677. **Lobb, R. K., A study of supersonic flows in a shock tube,** *Inst. Aerophys. Univ. Toronto, UTIA Rep.* **8**, 43 pp., 58 figs., May 1950.

Experimental results are reported for shock-wave and air-flow velocities measured by means of light screens forming miniature schlieren systems and deduced from oblique shock-wave angle for a 5°-3′ wedge placed in a test section at a distance of 4.5 ft from the diaphragm (recorded by schlieren photographs) in a shock tube of 14.75-in.² cross-section area and approximately 11-ft length. The results are rationalized on the basis of a unidimensional theory which takes into account the appearance of a centered rarefaction wave and a contact discontinuity (in internal energy) besides the principal shock wave treated as a plane discontinuity. Variation of specific heats and viscosity effects are neglected; the influence of the diaphragm break on the flow was observed, but it was accounted for only qualitatively. The deviation of experimental results from the theory is shown to be negligible up to diaphragm pressure ratios of 300:1. Discrepancies observed at higher pressure ratios are considered to be due mainly to a more complicated flow pattern (more complex expansion, transient shock waves) than that on which the theory is based.

According to reviewer, these discrepancies, especially as far as the shock-wave velocity is concerned, may be due to the insufficient distance between the test section and the diaphragm for a complete formation of the wave. This fact has been brought out recently by G. A. Lundquist [*J. appl. Phys.* **23**, 3, 374–375, March 1952], who, following the suggestion of J. Lukasiewicz [*Nat. Res. Counc. Canad.*, Rep. MT-10, Jan. 1950], made measurements of shock-wave velocities in a shock tube of 62 in.² cross-section area and demonstrated an excellent agreement between theory and experiment up to diaphragm pressure ratios of 10,000:1 (limit imposed only by experimental facilities) with the test section at a distance of 16.75 ft from the diaphragm, while, at a distance of 4.65 ft, the differences between the theory and experiment were similar to those reported by Lobb.

Antoni K. Oppenheim, USA

2678. **Bogdonoff, S. M., A preliminary study of Reynolds number effects on base pressure at M = 2.95,** *J. aero. Sci.* **19**, 3, 201–206, Mar. 1952.

Pressures acting on the base of a sting-supported, nonlifting body of revolution were measured in the wind tunnel at Reynolds numbers, referred to body length, varying from 0.6×10^6 to 18×10^6. The body consisted of a conical nose of 60° apex angle, followed by a cylindrical afterbody $2^1/_2$ diam in length. Data obtained for the body in a smooth condition showed that the ratio of base pressure to undisturbed stream pressure first decreased rapidly, then increased sharply, and finally decreased slowly with increasing Reynolds number. Author concludes from a study of schlieren photographs that these behaviors can be associated with laminar, transitional, and turbulent flow, respectively, in the free wake downstream of the body. Such differences as exist between these results and those obtained by Chapman [AMR **4**, Rev 2151] at Mach numbers of 1.5 and 2.0 are attributed to differences in model surface finish, airstream turbulence level, and the test Mach numbers. Data obtained at low Reynolds numbers with transition bands located just aft of the shoulder of the model could not be correlated with smooth-body data at high Reynolds numbers.

Reviewer believes results of these tests add significantly to existing information on base pressure characteristics of relatively blunt bodies. It remains to be determined if similar results obtain for more slender shapes, and if the transition strip is inadequate, independent of its nature and location.

Alfred J. Eggers, Jr., USA

2679. **Weinlich, K., Gas flow in a pipe, with friction and heat transfer** (in German), *Maschinenbau Wärmewirtsch.* **6**, 4, 61–65, Apr. 1951.

Paper deals with heat exchange and friction for the case of gas flow in a straight, horizontal duct having constant cross-sectional area. Derivations are based on the differential form of the energy equation including the terms for heat and friction. This equation is solved for perfect gases and the boundary conditions are discussed. For nonperfect gases the method to be followed in the solution of the various relations is indicated, but no actual derivation is completed. During the course of the paper, Euler, Rayleigh, and Fanno equations are obtained. The limiting conditions in the subsonic and the supersonic domains under various circumstances are discussed without reference to the entropy. Using the data of an experiment undertaken elsewhere, analytically obtained and experimentally measured values of pressure are compared, and it is shown that these agree well.

Reviewer believes that the paper is a contribution to the literature in that it discusses interesting but well-known phenomena in a concise form.

A. B. Cambel, USA

2680. **Hayes, W. D., Roberts, R. C., and Haaser, N., Generalized linearized conical flow,** *NACA TN* 2667, 48 pp., Mar. 1952.

Conical flow refers to flow in which the velocities are constant along rays through a fixed point; generalized conical flow of order n refers to flow in which the velocities are proportional to the nth degree of the distance from a fixed point. Present report develops a basic theory of generalized linearized supersonic conical flow for regions both inside and outside the basic Mach cone.

Applications are made to a pitching and rolling triangular wing and a family of thin sweptback triangular wings having symmetrical thickness distribution. For the latter cases, analytical expressions for the wave-drag and pressure coefficients are given and graphical results are presented for the wave-drag coefficients.

Authors attribute to G. N. Ward the fundamental idea from which their report stems. The method differs from either that presented by Germain [AMR **3**, Revs. 103, 2402] or that presented by Lomax and Heaslet [AMR **5**, Rev. 821].

Harvard Lomax, USA

2681. **Ferrari, C., On rotational conical flow,** *NACA TM* 1333, 12 pp., Feb. 1952.

See AMR **4**, Rev. 3312.

Turbulence, Boundary Layer, etc.

(See also Revs. 2662, 2669)

2682. **Wijker, H., Experiments on disturbed regions in the laminar boundary layer behind isolated surface excrescences for two- and three-dimensional flow,** *Nat. LuchtLab. Amsterdam Rap.* A.1267, 12 pp., 9 tables, 31 figs., Oct. 1951.

Report contains a number of photos of the disturbed regions behind protuberances in laminar boundary layers of two- and three-dimensional flow. Velocity profiles in these regions are

measured for two-dimensional flow. The construction of streamlines along the surface from measured pressure distributions in three-dimensional potential flow is given.

From author's summary

2683. **Timman, R., Method of characteristics and the calculation of the laminar boundary layer in three-dimensional flow** (in French), *Actes Coll. inter. Mécan.* **II**, *Publ. sci. tech. Min. Air, Paris*, no. 250, 251–259, 1951.

See AMR **4**, Rev. 4242.

2684. **Van Driest, E. R., Turbulent boundary layer on a cone in supersonic flow at zero angle of attack,** *J. aero. Sci.* **19**, 1, 55–57, 72, Jan. 1952.

Author found that, for turbulent boundary layers, the cone solution for local skin friction and heat transfer is the flat-plate solution corresponding to one half the Reynolds number on the cone, the Mach number and wall-to-free-stream temperature ratio remaining the same. This simple transformation rule is deduced using Prandtl's mixing-length theory. Reviewer remarks that, with the assumptions made—boundary layer is thin, pressure along rays from the origin of cone is constant, and wall temperature and shear stress at the surface have negligible variation with distance from origin—the same result can be achieved in a simpler and more general way.

Julius Rotta, Germany

2685. **Rebuffet, P., Lift augmentation of a sweptback wing by control of the boundary layer using air tapping on turbojet** (in French), *Actes Coll. inter. Mécan.* **II**, *Publ. sci. tech. Min. Air, Paris*, no. 250, 111–131, 1951.

Article describes experiments made on a high-speed wing-body combination without tail surfaces, angle of sweepback 31° 20′, Reynolds number approximating to that at take-off and landing of full-size airplane. Wings are hinged along three axes, one near nose, leading edge being deflectable downward, one just aft of midchord where suction is applied, and one midway between this one and trailing edge where there is blowing. These latter hinges allow a double flap effect. Air comes from jet engine (Nene), causing some loss of thrust. Suction is produced by a nozzle pointing into a bell-shaped opening, causing a Venturi effect at middle station, and original air and that sucked in are ejected together at rear station. Majority of experiments were performed at 30°–25°–45°, angles representing deflections from main chord line at the three stations starting from leading edge. Increased blowing gave increased lift due to prevention of separation, sink effect, and accelerated potential flow. Profile drag is decreased until separation is completely stopped, further blowing having little effect. It was found that configurations 0°–7.5°–15° or 0°–15°–15° were best for take-off. Small angles such as these required little blowing, thus reducing loss of thrust in jet engine. Author estimates that for airplane of 7000 kg at 30°–25°–45°, landing speed should be 160 kph with mass flow of 4 kg/sec from engine. At take-off for 0°–15°–15° optimum mass flow would be 2 kg/sec.

J. C. Cooke, Malaya

2686. **Pankhurst, R. C., and Gregory, N., Power requirements for distributed suction for increasing maximum lift,** *Aero. Res. Counc. Lond. curr. Pap.* **82**, 7 pp., Sept. 1948, published 1952.

Paper considers the power requirements for distributed suction. It appears that they are low for take-off and landing; no estimates can be made for the case of high-speed maneuvers until tests have been made under the conditions of compressible flow.

From authors' summary

2687. **Ogura, Y., The structure of two-dimensionally isotropic turbulence,** *J. meteor. Soc. Japan* **30**, 2, 59–64, Feb. 1952.

In meteorological problems, particularly in the lower atmosphere, it is useful to consider the air motion as being two-dimensionally isotropic turbulent. Author derives the two-dimensional analog of the Kármán-Howarth equation for the correlation functions f and g as well as the two-dimensional form of the equilibrium energy spectrum. The numerical values of the correlation coefficient and the spectrum differ very slightly from the three-dimensional case, though the functional forms are quite different. The calculated numerical values of the correlation coefficient for two-dimensional isotropic turbulence are in good agreement with hot-wire measurements in the atmosphere. Author concludes, therefore, that the three-dimensional form of the correlation coefficient may be used without serious error in studying the two-dimensional motion of air in the atmosphere.

Lawrence M. Grossman, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 2600, 2601, 2666, 2672, 2685)

2688. **Bird, J. D., and Jaquet, B. M., A study of the use of experimental stability derivatives in the calculation of the lateral disturbed motions of a swept-wing airplane and comparison with flight results,** *NACA Rep.* 1031, 25 pp., 1951.

See AMR **5**, Rev. 1503.

2689. **Sternfield, L., and Gates, O. B., Jr., A theoretical analysis of the effect of time lag in an automatic stabilization system on the lateral oscillatory stability of an airplane,** *NACA Rep.* 1018, 12 pp., 1951.

See AMR **3**, Rev. 2448.

2690. **Schade, R. O., Gates, O. B., Jr., and Hassell, J. L., Jr., The effects on dynamic lateral stability and controllability of large artificial variations in the rotary stability derivatives,** *Fairchild Publ. Fund, Inst. aero. Sci.*, Prepr. no. 350, 22 pp., Feb. 1952.

Large increments in the lateral rotary derivatives of aircraft are investigated. Problem is important when studying the stability of the lateral flight path. Linear artificial stability derivatives are used in calculations and in model free-flight analysis. Object is to decrease time to half amplitude of lateral oscillation while maintaining controllability and stability in the other modes.

Results show cross derivatives of yawing-moment-due-to-rolling velocity or acceleration and of rolling-moment-due-to-yawing velocity redistribute damping to the oscillation. This reduces the damping of the other lateral modes and generally brings poor flight qualities. Authors conclude that yaw damping increases the lateral damping, but can cause undesirable stiffness in turns. They suggest yaw damping or roll damping with addition of a cross derivative to damp oscillation without impairing flight characteristics.

F. W. Heilenday, USA

2691. **Seventh annual forum of the American Helicopter Society,** New York, Inst. aero. Sci., Apr. 1951, 159 pp. $5.50.

Papers covering the five phases of helicopter activity are presented: (**A**) Theory and design: (1) Helicopter rotor performance possibilities, by J. Stuart, III. (2) Effects of compressibility on the performance of two full-scale helicopter rotors, by P. J. Carpenter. (3) Service life of helicopter rotors, by R. Rosenbaum. (4) A study of design and economics of rotary wing gliders, by I. Benson. (5) The adaptation of gas turbines to helicopters, by P. H. L. Morain. (**B**) Development and test: (1) Demonstra-

tion of helicopters for the U. S. Navy, by J. W. Mazur. (2) A discussion of CAA policies, flight-test procedures, and civil air regulations for helicopters, by G. De Vore. (3) Testing machines for helicopter transmissions, by D. W. Botstiber. (**C**) Symposium on commercial operations, by C. M. Belinn, H. Boris, and C. Agar. (**D**) Symposium on military operations, by F. D. Foley, R. T. Kight and D. Condon. (**E**) Economics sessions: (1) Some lessons of the Liverpool-Cardiff helicopter service, by L. S. Wigdortchik. (2) Some economics and logistic aspects of the use of helicopters by the armed forces, by K. B. McCutcheon. (3) Economic prospects for large transport helicopters, by R. K. Waldo.

In **A**(1), lifting-rotor performance possibilities are examined in the light of blade stall and airfoil compressibility limitations. Maximum blade loadings and optimum rotor rotational speeds are estimated for various forward speeds. Possible performance of future helicopters is indicated. **A**(2) discusses the conditions at which compressibility losses reduce rotor efficiency, rate of growth of increased drag with increasing tip speed, and the point at which vibration and loss of control is reached. **A**(3) presents background which led to the present requirements as well as to offer several acceptable methods of showing compliance with the rotor fatigue requirements of the C.A.R. **A**(5) examines some of the reasons for the neglect of gas-turbine power plants by the helicopter industry and, finally, indicates the promising adaptation of these power plants to conventional and jet-type helicopters. **B**(1) discusses the background, requirements, methods, and procedures of demonstrating helicopters for the U.S. Navy. (**C**) discusses the practical application of helicopters covering operation, difficulties with present equipment, and expectations. (**D**) presents views on seagoing and ground operations.

From the above contents it is evident that these papers present a valuable collection describing the various phases of rotary wing activity. Leonard Goland, USA

2692. **Mitchell, K., with appendices by Frayn, Miss E. M., Lateral response theory,** *Aero. Res. Counc. Lond. Rep. Mem.* 2297, 57 pp., 1944, published 1952.

Report gives a general approach to the problem of lateral response of an aircraft, the aim being to establish certain modal response coefficients which could be made the basis of a numerical classification of response. Starting with the set of linear first-order differential equations of lateral stability, the determinantal equation is solved and the normal modes of free motion determined. The equations for the disturbed motion are solved both by the method of variation of constants and by the Laplace transformation. The modal response coefficients are the amplitudes to which the various normal modes are excited when the aircraft is subjected to unit disturbance (e.g., unit sideslip velocity, unit impulsive rolling moment, etc.) Using these modal response coefficients, formulas for the motions resulting from any arbitrary control application can be determined easily.

Routine methods and tables for calculating these coefficients and the response curves are given in the appendixes.

A. W. Babister, Scotland

2693. **Palme, H. O., Approximate methods to transform air inlet losses measured in low-speed wind tunnels to varying flight conditions,** *SAAB Aircr. Co., Linköping TN* 2, 11 pp., 1951.

Paper presents a brief analysis, based on one-dimensional compressible flow theory, to the calculation of inlet losses for jet-engine air intakes. A method for estimating losses in high-speed flight conditions based on low-speed wind-tunnel tests is outlined. M. J. Thompson, USA

2694. **Muggia, A., On the calculation of propeller-wing interference** (in Italian), *Atti Accad. naz. Lincei R. C. Cl. Sci. Fis Mat. Nat.* (8) **11,** 1/2, 53–57, July/Aug. 1951.

The change of the lift distribution along the wing span due to a propeller located in the middle of the wing is calculated. It is assumed that inside the slipstream the axial velocity component is constant and the circumferential velocity component is zero. The boundary conditions on the surface of the slipstream are fulfilled by adding vortexes inside and outside the slipstream.

The calculation of the induced angles of attack across the wing span leads to an integral equation determining the lift distribution. The integral equation is solved by means of a finite trigonometric series in a manner similar to the process used by Multhopp. No examples or tables facilitating numerical calculations are published.

Reviewer assumes that neglect of the circumferential velocity component in the slipstream will cause remarkable differences between this theory and an actual problem of propeller-wing interference. Gerhard W. Braun, USA

2695. **Cunsolo, D., Joukowsky profile with a rounded tip** (in Italian), *Aerotecnica* **32,** 1, 20–24, Feb. 1952.

2696. **Muggia, A., On wing-body interference at subsonic velocities** (in Italian), *Monogr. Lab. Aero. Politecn. Torino*, 14 pp. = *Atti Accad. Sci. Torino* **85,** 1950–1951.

Author remarks that velocities induced by fuselage are not affected by the compressibility factor. Thus, even in the case where one considers a fluid which is compressible but flowing at subsonic speeds, it is possible to utilize the method of calculating the lift distribution over a wing-body combination that was originally developed by Multhopp under the restricted assumption of incompressibility [See Multhopp, H., *Luftfahrtforsch.* **18,** nos. 2–3, 1941], by the mere inclusion of the Prandtl-Glauert factor into Multhopp's expression for the circulation distribution along the span of his fictitious wing (the one into which the actual wing is transformed conformally, and in such a way as to bring the cross-sectional outline of the fuselage over into a doubled piece of flattened line-segment lying along the vertical axis).

A sample calculation for an unswept but tapered wing is carried through by use of numerical integrations. Plots of spanwise lift distributions over the wings and fuselage (circular cross section) for several Mach numbers and various widths of fuselage are presented, together with the corresponding calculations of lift-curve slopes and induced angles of attack at the wing and at the tail, which is placed a half-chord length aft of the wing trailing-edge, five times this distance, and infinitely far downstream (the fuselage is also assumed to be infinitely long for this latter case). Although many calculational details are given, no experimental checks are provided, but, of course, the distributions obtained exhibit dips over the fuselage area which are similar to the ones depicted by Lennertz for the incompressible case in Durand, "Aerodynamic theory" [p. 154, vol. IV], save that now the progressive modifications due to higher and higher subcritical Mach numbers are furnished. R. H. Cramer, USA

2697. **Beavan, J. A., and Rogers, W. E., High-speed wind tunnel tests on an aerofoil with and without two-dimensional spanwise bulges,** *Aero. Res. Counc. Lond. curr. Pap.* 78, 11 pp., 20 figs., Feb. 1951, published 1952.

Results from high-speed wind-tunnel tests on a 5-in. chord pressure-plotting airfoil having a single spanwise bulge on each surface have been compared with those obtained from the plain airfoil (R.A.E. 104 section; $t/c = 0.10$). The comparison has been

made at incidences 0, ± 2°, ± 4°, for a limited range of Mach number; the test Reynolds number was between 1.5 and 1.9 million.

One bulge had a maximum height of 0.004 chord and extended from 0.3 to 0.5 chord. The other bulge was half of both these dimensions. The experimental pressure distributions at low speeds for both surfaces agree with those predicted by theory. The C_L is generally greater than for the plain airfoil, but the corresponding changes in C_m are small except at the higher speeds.

At low speeds and zero incidence, boundary-layer transition took place at about the bulge centers (0.4 chord) compared with 0.75 chord for the plain airfoil; the resulting increase in C_D agrees with theory. With increase in Mach number, an initial rise in drag (due to shock waves on the bulge) occurs at both 0° and 2° incidence. This rise is halted as the main shock wave and transition point move back, and the final drag rise takes place at about the same Mach number as on the plain airfoil.

The shock pattern is considerably modified by the presence of the bulges, the waves being stronger and more well-defined than on the plain airfoil. This is due to the higher local Mach number achieved ahead of the shock in the former case.

From authors' summary

2698. Phillips, W. H., Theoretical analysis of some simple types of acceleration restrictors, *NACA TN* 2574, 35 pp., Dec. 1951.

Analyses were made of aircraft acceleration restrictors which stop elevator motion when accelerometer indicates certain value. Investigations included accelerometer at center of gravity, and three chord lengths ahead of center of gravity, for representative fighter and transport at sea level and 40,000 ft. It was found that such systems result in limitations of rate of elevator movement which are unsatisfactory for maneuverability at low speed. A system which stops elevator travel at present value of true airspeed times pitching velocity was found satisfactory for static margin greater than 15% MAC, particularly if elevator motion is allowed to start again when value of product falls below preset value.

It seems to reviewer that scope of investigation was unduly restricted by limitations on instrumentation considered. For instance, author remarks that a system sensing a combination of pitching acceleration and normal acceleration might be suitable, but that investigation is limited to such combinations of these quantities as are obtainable by locating a single accelerometer at nose of aircraft. A system combining these quantities in any ratios whatever, is, of course, readily obtainable by the use of sum and difference circuits and two linear accelerometers or linear and angular accelerometers. A. H. Flax, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 2542)

2699. Mazelsky, B., Numerical determination of indicial lift of a two-dimensional sinking airfoil at subsonic Mach numbers from oscillatory lift coefficients with calculations for Mach number 0.7, *NACA TN* 2562, 38 pp., Dec. 1951.

The lift and moment for a sudden change in angle of attack of a two-dimensional flat plate in subsonic potential flow are calculated numerically for a Mach number of 0.7 by means of Garrick's reciprocal relations, using Possio's numerical solution for the harmonic oscillation values. This numerical solution for k_1 (indicial lift) is then used to numerically evaluate k_2, the indicial lift upon entering a sharp-edged gust.

Both k_1 and k_2 were found to predict a slower growth of lift than in the incompressible case. However, reviewer notes that the numerical values for k_1 at $M = 0.7$ do not form a logical variation when compared with the values given for $M = 0.8$ in *NACA TN* 2403. The k_1 values from *TN* 2403 predict a more rapid growth of lift than do the values computed by the reciprocal relations used in this report.

Reviewer believes the reciprocal relations used are incorrect; see E. V. Laitone (second following review).

E. V. Laitone, USA

2700. van de Vooren, A. I., Generalization of the Theodorsen function to stable oscillations, *J. aero. Sci.* **19**, 3, 209–211, Mar. 1952.

A generalized Theodorsen function $C(k, s)$ is defined for a wake of finite length sb (b = semichord). The vortex strength at the point x is a function of $(s - x)$. For unstable and harmonic motions, the vortex strength approaches to a distribution of the type exp $ik\ (s - x)$ if $s - x \to \infty$. Under these conditions $C(k, s) \to C(k)$, the Theodorsen function, as $s \to \infty$.

However, the same reasoning may not be applied to stable motions, since in this case the initial disturbance influences the wake. Using Laplace transformations it is shown that, for stable motion, the vorticity decreases as s^{-3} and not as exp(iks), and $C(k, s)$ is oscillatory divergent. This throws some doubt on the validity of the results of Luke and Dengler [AMR **5**, Rev. 221; see also the three following reviews].

A simple formula is given for $C(k, s)$ which could be used for the calculation of aerodynamic forces by the usual formulas of Theodorsen [*NACA TR* 496] and is valid for both stable and unstable motions.

It is shown that the motion of an oscillating wing can be calculated exactly if $C(k)$ is known for Im$k < 0$, even if the motion is stable. A. W. Babister, Scotland

2701. Laitone, E. V., Theodorsen's circulation function for generalized motion, *J. aero. Sci.* **19**, 3, 211–213, Mar. 1952.

Using work of Sears [*J. Franklin Inst.*, July 1940], it is shown that Theodorsen's circulation function cannot be applied to stable damped motions by simply replacing the imaginary parameter by a complex one [see preceding and two following reviews]. However, using Laplace transformations, a new function is defined from which the lift can be obtained for a wake of finite length.

It is shown that the indicial response (or lift deficiency) function of von Kármán and Sears [*J. aero. Sci.* Aug., 1938] is the fundamental function that satisfies all the reciprocity relations between Wagner's step-function response and Theodorsen's steady-state sinusoidal response, and can be applied by means of the Duhamel integral to all motions, including gust loadings.

A. W. Babister, Scotland

2702. Jones, W. P., The generalized Theodorsen function, *J. aero. Sci.* **19**, 3, p. 213, Mar. 1952.

Author criticizes work of Luke and Dengler [AMR **5**, Rev. 221] in extending the Theodorsen function C to stable damped motions by analytic continuation, since the analysis breaks down for a wake of infinite length in this case (see also the two preceding and the following reviews), the lift function depending on the initial disturbance and the distance traveled. Author agrees with van de Vooren (the second preceding review) in doubting the validity of the tables for the generalized Theodorsen function given by Luke and Dengler. A. W. Babister, Scotland

2703. Dengler, M. A., Goland, M., and Luke, Y. L., Notes on the calculation of the response of stable aerodynamic systems, *J. aero. Sci.* **19**, 3, 213–214, Mar. 1952.

Authors discuss technique used in their earlier paper [AMR **5**,

Rev. 221] in the light of criticisms of the three preceding reviews. They show that, when the exponential approximation is used for the Wagner function, excellent agreement is obtained in both stability and response studies of damped systems.

Secondly, analytic continuation of the Theodorsen function $C(k)$ in the stable half plane gives results consistent with the exponential approximation.

The generalized function $C(k, \tau)$ is considered for a wake of finite length τ, the vorticity at the point x varying as $\exp ik(s - x)$. This is expressed as the ratio of two integrals. For convergent motions, both the numerator and denominator of this ratio are oscillatory divergent as $\tau \rightarrow \infty$. However, writing the numerator and denominator as infinite series (each term representing the area under one half of a wave along the τ axis) and summing by Euler's transformation method, the limit of the ratio so obtained is equivalent to the definition of $C(k)$ by analytic continuation. Reviewer notes that van de Vooren's work (the third preceding review) would invalidate this approach since the vorticity decreases as τ^{-3} and not exponentially for stable motions.

Authors offer no definite mathematical or physical proof of their approach, but show that it is adequate for practical purposes for obtaining time histories of the motion of both stable and unstable systems. A. W. Babister, Scotland

2704. **Barmby, J. G., Cunningham, H. J., and Garrick, I. E., Study of effects of sweep on the flutter of cantilever wings,** *NACA Rep.* 1014, 25 pp., 1951.

See AMR **4,** Rev. 1309.

Propellers, Fans, Turbines, Pumps, etc.

(See also Rev. 2693)

2705. **Pinkel, B., and Karp, I. M., A thermodynamic study of the turbine-propeller engine,** *NACA TN* 2653, 90 pp., Mar. 1952.

Equations and charts useful in computation of performance and performance-parameters are presented. Two types of turbine-propeller engines are discussed: The one in which a single turbine drives both the compressor and the propeller, and the one in which two turbines are provided to drive the compressor and the propeller independently. The presented charts allow determination of performance parameters from component efficiencies and operating conditions. It is claimed that the evaluation of the engines treated is faster if the present method is used than if previous methods are employed. Also, good accuracy for the results is claimed. Reviewer believes this latter claim is somewhat astonishing, since several approximations and simplifications are introduced in the analysis.

The basic equations and performance parameters are derived first. Then, a detailed discussion of the charts and their use is given. The accuracy of the method is compared with step-by-step evaluation of conditions. The turbine-propeller engine performance is presented next by discussing "design-point engines" and an "engine with given set of matched components."

Paul Torda, USA

2706. **Kartvelishvili, N. A., On temporary irregular running of hydraulic turbines, in particular, high-speed turbines** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **75,** 5, 625–628, Dec. 1950.

A sudden change of turbine load produces a transitory change in rpm of the water turbine and a change of the frequency of the generated alternating current. The relative frequency change $\Delta\varphi(t)$ during the regulation process (time t) is approximately determined under three simplifying assumptions: (1) After the sudden change, the turbine load remains unchanged. Hence the moment of the electric load is considered as a known function of the frequency (in the general case, in addition, a certain relation between load and time has to be considered). (2) The torque of the turbine depends on the pressure existing in the volute casing before the guide vanes, and on the square of the revolutions and frequency, respectively. (3) The sudden load change causes a water hammer in the volute casing, whose intensity along the volute casing may vary.

For the dependence under (2), the average value of the changed pressure, caused by the water hammer, is assumed. The difference between the turbine torque and the moment of the electric resistance is proportional to the rpm change and frequency change ($d\Delta\varphi/dt$), respectively. From there, considering the assumptions (1) to (3), a differential equation is established which, neglecting the higher powers of the unknown $\Delta\varphi(t)$, can be reduced to a linear differential equation.

M. Strscheletzky, Germany

2707. **Jackson, G., The effects of atmospheric humidity and temperature on the engine power and take-off performance of a Hastings 1,** *Aero. Res. Counc. Lond. curr. Pap.* 77, 20 pp., 8 tables, 10 figs., Feb. 1950, published 1952.

Flight tests have been made to assess the effect of changes in humidity on the engine power, fuel flow, and take-off performance of a Hastings 1. The investigation also enabled the effect of changes in air temperature to be deduced.

It has been established that engine power decreases with increasing humidity and that the reduction is greatest at take-off engine speed and boost. Independent meteorological information suggests that the specific humidity will rarely exceed $2^1/_2\%$. The investigation has shown that this degree of humidity causes a reduction in take-off power of approximately 10% compared with operation in completely dry air at the same temperature. Two thirds of this reduction are accounted for by the displacement of dry air and the effective enrichening of the mixture; the remainder is attributed to the effect of humidity on the combustion process. For $2^1/_2\%$ humidity, the increase in take-off distance to clear a 50-ft screen is calculated to be 17%. For the specification of take-off conditions, humidity is a parameter of the same order of importance as temperature. At constant humidity, the rate of decrease of power with increase of temperature is not significantly different from the value given by the standard formula below full throttle height.

No effect of humidity on fuel consumption has been detected. The rate of decrease of fuel consumption with increase of temperature is consistent with the assumption of constant indicated specific consumption except at take-off rating, when the decrease is greater than that corresponding to this assumption.

From author's summary.

Flow and Flight Test Techniques

(See also Revs. 2670, 2674)

2708. **Petherick, E. J., Digital recording and analysing of flight test data: a proposed system,** *Aero. Res. Counc. Lond. curr. Pap.* no. 75, 7 pp., Nov. 1950, published 1952.

A small digital recorder is proposed to punch 10,000 instrument readings on 100 ft of cine film, each item to 3 decimal or 12 binary places. Any number of instruments could be recorded, at 10 readings a second. A further unit is envisaged, to read the punched data; to correct each item for instrument errors; to dis-

play the corrected values; and to punch them on Hollerith cards or RAESCC tape. From author's summary

2709. Cooley, W. C., and Stever, H. G., Determination of air velocity by ion transit-time measurements, *Rev. sci. Instrum.* **23,** 4, 151–154, Apr. 1952.

A method is described for measuring the velocity of an airstream by producing positive ions at one point in the flow and measuring the time required for the ions to be carried to an induction-type detector located a known distance (0.5 to 2.0 in.) downstream. Positive ions are produced intermittently near the tip of a positive corona point by burst discharges, which are initiated by stray ions in the airstream or by irradiating the air in the neighborhood of the positive corona point with polonium alpha particles. The ion transit-time is measured by observing the induced pulses from the detector on a cathode-ray oscillograph sweep which is triggered by the burst discharges of the corona point. The accuracy of velocity measurement using a measuring length of one inch with a free-stream air velocity of 1730 fps (based on pressure and temperature measurements) was better than 2%. It is shown that the direction of streamlines in a supersonic flow can be determined approximately by aligning the corona point and the induction detector probe to give the maximum amplitude of induced pulses. It is believed that this method may be applied to map velocity fields in supersonic wind-tunnel experiments. From authors' summary

2710. Coffin, K. P., and Bauer, S. H., Apparatus for imposing and measuring rapid pressure changes in gases, *Rev. sci. Instrum.* **23,** 3, 115–118, Mar. 1952.

A simple apparatus is described in which rapid volume changes can be imposed on a small reaction vessel by means of a bellows and cam arrangement. Thus, pressure increments of the order of 10-mm Hg can be induced in about 2 milliseconds. The pressure changes during the expansion or compression, and the subsequent adjustment to equilibrium in case the vessel is filled with a dissociating gas is followed by a Massa Sound pickup (piezoelectric unit). The sensitivity of the apparatus is such that a $\Delta p = 6.7$ mm gives an inch deflection on the oscilloscope. Limitations of the present design and possible improvements for increased stability and sensitivity are discussed.

From authors' summary

2711. Patterson, J. L., A miniature electrical pressure gage utilizing a stretched flat diaphragm, *NACA TN* 2659, 47 pp., Apr. 1952.

A variable-air-gap inductance type of electrical pressure gage is described that is basically $^7/_{16}$ in. in diam and $^1/_4$ in. in thickness. The gage was designed to measure pressures fluctuating at high frequencies. It is also capable of measuring steady-state pressures with errors of less than 1% of full scale, and has proved to be of value as a general-purpose electrical gage for aeronautical work where small size and minimum response to acceleration forces are important factors.

Design equations and curves are presented which can be used to predict the deflections and fundamental natural frequencies of stretched flat diaphragms.

From author's summary

2712. Lindorf, H., Methods of temperature measurement (in German), *Feinwerktech.* **56,** 3, 67–73, Mar. 1952.

A survey of various types of instruments, their temperature ranges, and accuracies.

N. Holm Johannesen, England

Thermodynamics

(See also Revs. 2662, 2665, 2671)

2713. Crocco, L., Aspects of combustion stability in liquid propellant rocket motors. Part I: Fundamentals. Low frequency instability with monopropellants. Part II: Low frequency instability with bipropellants. High frequency instability, *J. Amer. Rocket Soc.* **21, 22;** 6, 1; 163–178, 7–16; Nov. 1951, Jan.-Feb. 1952.

Problem of low-frequency combustion instability in both monopropellant and bipropellant rocket motors is discussed and a theory for this phenomenon is advanced, based on the assumption that time lag between injection of propellant and transformation into hot gases is affected by pressure and pressure variation. It is shown that self-excited oscillations can exist for constant injection rate. Practical fuel systems are, however, sensitive to combustion-chamber pressure, and the effect of variable injection rate is discussed. High-frequency instability is analyzed by considering a simplified distribution of combustion in the chamber. General application of the results to actual models is discussed. J. C. Wisdom, Australia

2714. Boedewadt, U. T., and Engel, R., Remarks on the calculation of combustion (in French), *Rech. aéro.* no. 26, 19–30, Mar./Apr. 1952.

Discussion of graphs and special notation designed to aid rapid calculation of equilibrium properties of products of combustion.

Bruce L. Hicks, USA

2715. Dugger, G. L., and Graab, Dorothy D., Flame speeds of 2,2,4-trimethylpentane-oxygen-nitrogen mixtures, *NACA TN* 2680, 25 pp., Apr. 1952.

Flame speeds have been measured by method of schlieren cone area on apparatus developed by the senior author [AMR 4, Rev. 3691]. Tests are made at three initial temperatures and five different oxygen-nitrogen ratios containing more oxygen than air. Special attention is paid to the maximum flame speed which is shown to depend upon initial temperature T_0 and mole fraction oxygen α by $U_{\max} = 0.133 T_0^{1.40}(\alpha - 0.120)$. A comparison of this empirical formula with prediction of both thermal theory and diffusion theory gives agreement within 20%. Neither theory has the correct simple linear form in α.

Howard W. Emmons, USA

2716. Broeze, J. J., Theories and phenomena of flame propagation, Third Symp. Combust. Flame Expl. Phenom.: Baltimore, Md., Williams & Wilkins, 146–155, 1949. $13.50.

After introductory remarks on ignition and rate of energy release in homogeneous and in propagating combustion zones, author outlines some studies of his group on Bunsen flames, namely: Deformation of streamlines; flame position as determined by flame luminosity, schlieren photography, and smoke particles; flame speed measurement; and flame stability.

Bruce L. Hicks, USA

2717. Culshaw, G. W., and Garside, J. E., A study of burning velocity, Third Symp. Combust. Flame Expl. Phenom.: Baltimore, Md., Williams & Wilkins, 204–209, 1949. $13.50.

Measurements of burning velocities of mixtures of carbon monoxide, ethylene, and propane with air were made using Gouy method in which velocity is rate of gas flow into burner divided by flame cone area, with area measured at outside of luminous cone. Authors found velocity independent of burner diameter above minimum value. They attribute diameter effect to region of reduced burning velocity near rim, caused by interdiffu-

sion of products and unburned gas. Hypothesis was substantiated by analysis of gases. Reviewer notes reduction of velocity near rim has been noted elsewhere, though attributed to loss of heat and chain carriers to rim [Lewis and von Elbe, AMR **5**, Rev. 2492]. Use of shadow cone revealed by shadowgraph, rather than outer boundary of luminous cone, has recently been advocated [Andersen and Fein, *J. chem. Phys.* **18**, 441–3, 1950]. Comparison of methods is given by Ashforth, Long, and Garner [*J. chem. Phys.* **18**, 1112–13, 1950].

Marjorie W. Evans, USA

2718. **Cassel, H. M., Das Gupta, A. K., and Guruswamy, S., Factors affecting flame propagation through dust clouds,** Third Symp. Combust. Flame Expl. Phenom.: Baltimore, Md., Williams & Wilkins, 185–190, 1949. $13.50.

The Mallard-Le Chatelier picture of the combustion wave is amended by adding a term for radiant heat transfer. On introducing the rate of oxygen diffusion toward individual particles, an expression for the burning velocity in dust clouds is obtained, representing its dependence on thermal conductivity, burning and ignition temperatures, radiation characteristics of the dust cloud, dust concentration, and particle size.

This serves as working hypothesis in conducting experiments on the effect of those factors upon stationary dust flames and flames traveling through quiescent dust clouds.

Results obtained with atomized aluminum are: (1) On the lean side of the stoichiometric ratio the burning velocity increases with increasing concentration. (2) The burning velocity increases with decreasing particle size in the range studied. (3) The failure to produce stationary dust flames with burner tubes smaller than $^1/_2$-in. diam indicates an effect of "radiation quenching" close to the rim in high-temperature dust flames. (4) A striking increase in the flame velocity of closed-end ignited dust flames is attributed to turbulence.

The experimental results are in qualitative agreement with theoretical expectations. From authors' summary

2719. **Thring, M. W., The science of flames and furnaces,** New York, John Wiley & Sons, Inc., 1952, xiv + 416 pp. $6.50.

Old established industries such as steel, cement, and ceramics, developed process furnaces during the early days of science and technology. In the intervening years the advancement of the art has been slow, whereas science and technology have made tremendous strides on many fronts. From the wealth of modern scientific and engineering knowledge, Thring has collected, organized, and highlighted those portions applicable to furnace design and operation. The book was written to guide and inform furnace operators; to interest researchers in gaps in fundamental knowledge underlying furnace problems; and to assess the present status of the science of furnace design.

The furnaces considered are limited to the class burning conventional fuels. In the first chapter, descriptions are given of the various types in common use in the metals, refractories, chemical, cement, glass, and coal-carbonization industries; included are data on physical arrangements, process operation, material charges, flows of air and fuel, and other details. Several general schemes of classification are presented.

The main concern of the book is: To apply the systematized fields of knowledge to furnace design and operation; to present a concise picture of the status of the knowledge; and to indicate profitable directions for research. A chapter is devoted to each of the following subjects: The thermodynamics of the heating process; the kinetics of combustion; heat transfer; the aerodynamics of hot gas flows; and methods and materials of construction.

The thermodynamics of furnace processes is developed from the first and second laws. Examples of energy balances are given. Instead of a widespread use of entropy, the author employs a "virtue" of energy; this is a Carnot efficiency factor. Graphical methods are stressed.

The chapter on the liberation of heat by combustion starts with a brief account of reaction kinetics and the thermodynamics of combustion. The basic phenomena relating to the combustion of solid liquid and gaseous fuels receive brief but adequate treatment; included subjects are flame propagation, laminar and turbulent flames, surface combustion, the mechanism of combustion in solid fuel beds, and the atomization and burning of liquid fuels. Furnace control and instrumentation complete the chapter.

The conventional formulas for convective, radiative, and conductive heat transfer are applied to problems of furnace design and operation. The applications include clear statements of the steps taken in practical furnace calculations; this is excellent training in the methodology of heat-transfer analysis of a system. The problems and methods of high-temperature measurement receive some attention.

The chapter on the aerodynamics of hot systems attempts to answer the two basic problems: how to calculate the total quantity of gas that will flow through the system, and how to predict the pattern of gas flow in specific parts of the system. Formulas for pressure drop for various types of flows are given; some of them are flows through channels, orifices, Venturis, bends, changes of section, beds of solid particles, and regenerators. The results of some of the latest investigations on jets and jet mixing are cited. The experimental methods for studying gas flows include discussions of velocity measurement, flow visualization, and the radon technique. The use of models receives a brief but excellent treatment.

A short chapter presents data on refractories and furnace construction. The availability, physical properties, resistance to chemical attack, and other factors governing the selection of refractories are stated. Various precautions in the use of refractories in high-temperature construction are stressed, and constructional features are illustrated and explained.

The final chapter is devoted to the application of the scientific method to furnaces. By means of it, the operation of an existing furnace could be examined for improvement; a class of furnaces can be studied to improve the type; modifications of existing types can be piloted; operational difficulties can be rationally diagnosed; and leads toward the development of radically new furnaces may be gotten. To provide a scientific basis for studying furnace performance, a short account of the application of statistics is given.

The internal organization of each chapter is well worth comment: Thring starts with first principles or a short account of basic scientific investigations; from the fundamentals, the reader is led to the practical equations for furnace calculations. Many references to other books and numerous original investigations enable the serious student to acquire a more solid background—and Thring discusses the literature critically in perspective and in the manner of one who has thoroughly digested the diverse original works. A summary at the end of each chapter outlines the important concepts and equations of each subsection. Numerous graphs and tables of data provide data for practical calculations; indeed, for preliminary calculations there is little need to search for additional data. When involved analyses are made, sample calculations are presented, or the steps to perform the calculation are explicitly stated. A high degree of rigor and lucidity is maintained with an economy of words; the lucidity is partly the result of a clear logical line of thought in the development of the subject.

The reviewer highly recommends this book to furnace designers and operators. It presents a valuable fund of practical

information embedded in the mosaic of a rigorous presentation of the pertinent parts of modern science and engineering. Researchers in the germane parts of heat transfer, thermodynamics, fluid mechanics, and combustion can obtain a practical perspective from this book. Finally, it is an excellent example of how this type of technical book should be written.

H. E. Robison, USA

2720. Verschaffelt, J. E., On thermomechanics of irreversible phenomena (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* (5), **37**, 8-9, 691-695, 1951.

Author corrects the wrong assumption in *Acad. roy. Belgique, Bull. Cl. Sci.* (5) **36**, 962-983, 1950, that the partial derivative of the thermodynamic potential of one compound with regard to pressure at constant temperature and concentration equals the specific volume of the mixture. The original conclusion that a pressure gradient does not affect diffusion but produces only a net flow of the whole mixture is also corrected.

Lothar Meyer, USA

2721. Hill, T. L., Statistical thermodynamics of the transition region between two phases. II. One component system with a plane interface, *J. chem. Phys.* **20**, 1, 141-144, Jan. 1952.

An approximate statistical theory based on hard sphere models is used to calculate the density-transition curve between a one-component liquid and its equilibrium vapor phase. This density curve is related thermodynamically to the surface tension, the surface energy, the position of the Gibbs' surface of tension, and to the dependence of surface tension on curvature. The calculations are compared with those of Kirkwood and Buff based on similar theories and with experimental values for argon.

Joseph Kaye, USA

2722. Brown, W. B., and Longuet-Higgins, H. C., The statistical thermodynamics of multicomponent systems, *Proc. roy. Soc. Lond.* (*A*) **209**, 1098, 416-418, Nov. 1951.

Continuing the second author's study of mixtures which he calls "conformal solutions" [AMR **4**, Rev. 4608], the authors write down the results of calculation of a second approximation under an additional assumption. They conclude that second-order quantities are not expressible in terms of the thermodynamic properties of the "reference species" (dominating component).

C. Truesdell, USA

2723. Gunn, J. C., Relaxation time effects in gas dynamics, *Aero. Res. Counc. Lond. Rep. Mem.* 2338, 44 pp., Apr. 1946, published 1952.

Flow of gases (1) in a wind tunnel, (2) around an airfoil, (3) through shock waves is examined under the postulate that the internal energy of the gas may be considered as equal to the sum of an energy of translation, rotation, and vibration. The translational and rotational degrees of freedom are considered to have their equilibrium values, while the vibrational modes are postulated to require a relaxation time.

Myron Tribus, USA

2724. Ward, J. C., and Wilks, J., The velocity of second sound in liquid helium near the absolute zero, *Phil. Mag.* (7) **42**, 326, 314-316, Mar. 1951.

According to Landau's two-fluid model and in agreement with experiment, the velocities of first and second sound are related by the equation: $c_2 = c_1/3^{1/2}$. This relation is derived by the authors without any reference to two fluids from a model in which sound waves are propagated in a phonon gas, thus giving rise to periodic variations in the phonon density. The model applies to crystals as much as to helium II. Authors intend, accordingly, to look for the second sound in a corundum crystal at helium temperatures.

R. Eisenschitz, England

2725. Ward, J. C., and Wilks, J., Second sound and the thermomechanical effect at very low temperatures, *Phil. Mag.* (7) **43**, 336, 48-50, Jan. 1952.

The velocity of second sound is derived from the authors' model (see preceding review) in a direct and very simple way. The following assumptions are necessary: (1) Approximate position and momentum can be assigned simultaneously to a phonon similarly as in the theory of thermal conduction. (2) The distribution function in phase space satisfies a Boltzmann integro-differential equation. (3) Collisions between phonons conserve energy and momentum. Whereas no attempt is made to justify the above model or assumptions, the authors' approach is obviously of great heuristic value. It provides a simple picture for the thermomechanical effect in helium by interpreting it as the osmotic pressure of phonons dissolved in the superfluid, capillary acting as a semipermeable membrane.

R. Eisenschitz, England

2726. Fierz, M., On the theory of condensation (in German), *Helv. phys. Acta* **24**, 4, 357-366, Sept. 1951.

Using statistical mechanics, condensation is shown to occur at sufficiently low temperature for a gas whose atoms attract each other. Surface tension is shown to be a decisive factor for the formation of two phases. The point of condensation results as a singularity of the equation of state, where the pressure assumes a well-defined value while the density is indeterminate.

T. Y. Toong, USA

Heat and Mass Transfer

(See also Revs. 2742, 2750)

2727. van der Held, E. F. M., The contribution of radiation to the conduction of heat, *Appl. sci. Res.* (*A*) **3**, 3, 237-249, 1952.

Different values of thermal conductivity of insulating materials are sometimes obtained by transient and stationary methods of measurement.

By combining a term representing contribution of radiation to the original terms of Fourier's equation for conduction of heat, an integrodifferential equation is obtained. A second equation connecting radiation (I) from and to (J) of a small element of volume is set up on assumption of diffuse radiation. These two equations, together with boundary conditions, determine solutions of the problem.

Examination of these equations shows that at a point far removed from boundaries, the normal equation of Fourier for heat conductions holds in steady state, but with apparent conductivity greater than the real one; and for unsteady state, a modified form of Fourier's equation is obtained.

Two types of problems are solved for unsteady state, (a) those which can be solved by separation of variables, and (b) heat-source problems. In particular, temperature distribution around an electrically heated wire in a fibrous insulator is obtained, and a maximum value for apparent conductivity of material is derived. Work of the paper is to be continued by author.

William A. Wolfe, Canada

2728. Squire, W., A problem in heat conduction, *J. appl. Phys.* **22**, 12, 1508-1509, Dec. 1951.

In a medium of infinite extent moving with constant velocity, there is a fixed point-source of heat that generates heat at a rate proportional to sin ωt or cos ωt. Using classical methods and

the Dirac delta function, author obtains a formula for the simple periodic temperatures with frequency ω in the medium.

R. V. Churchill, USA

2729. **Bryson, A. E., and Edwards, R. H., The effect of nonuniform surface temperature on the transient aerodynamic heating of thin-skinned bodies,** Fairchild Publ. Fund, Inst. aero. Sci. Prepr. **365,** 14 pp., 4 figs., 1952.

A quasi-steady analysis is presented of the transient forced-convection heating of bodies with thin metallic skins, where the boundary layer is laminar and taking into account the effect of nonuniform surface-temperature distribution on rate of heat transfer.

The equation

$$G\,\frac{\partial T_s(x,t)}{\partial t} = \frac{-At}{x^{1/2}}\int_{\xi=0}^{x}\frac{d[T_s(\xi,t)-T_e(t)]}{[1-(\xi/x)^{3/4}]^{1/3}}$$

where $\qquad A(t) = 0.332(U/\nu)^{1/2}(c_p\mu/k)^{1/3}k$

is solved in a closed form for an arbitrary velocity variation and initial temperature. In particular, a solution is obtained for the case of an exponential decrease of velocity with time and constant initial temperature.

The solutions are given analytically and in graphical form. These more exact solutions are compared with solutions obtained by assumption of an "isothermal heat-transfer coefficient." Authors point out that temperatures calculated by both methods are in fairly good agreement, but that heat-transfer coefficients calculated from the more exact solution may differ greatly from those predicted by isothermal surface theory.

William A. Wolfe, Canada

2730. **Ohji, M., An approximate calculation of the laminar nonisothermal flow in a circular pipe. I,** *Rep. Res. Inst. appl. Mech., Kyushu Univ.* **1,** 2, 23–28, Apr. 1952.

An approximate temperature distribution is derived for Poiseuille flow in a circular pipe. It satisfies the equation $wT_z = k(T_{rr} + r^{-1}T_r)$ for $r = 0$ and $r = a$ (T is temperature; r and z cylinder coordinates; a pipe radius, w velocity ($w \sim 1 - r^2/a^2$); k thermometric conductivity; suffixes indicate partial derivatives) and the boundary conditions $T(0, r) = T_1$; $T(z, a) = T_2$ for $z > 0$; $T_r(z, 0) = 0$, as well as the integral form ${}_0\int^a wT_z r dr = {}_0\int^a k(T_{rr} + r^{-1}T_r)r \cdot dr$. Comparison is made with Graetz's and Lévêque's solutions.

H. Wijker, Holland

Acoustics

(See also Revs. 2724, 2725)

2731. **Ingård, U., and Pridmore-Brown, D., Propagation of sound in a duct with constrictions,** *J. acoust. Soc. Amer.* **23,** 6, 689–694, Nov. 1951.

Quantitative analysis is made of propagation in a duct periodically loaded with constrictions (iris partitions) of various apertures with both hard and attenuating side walls. Assuming low enough frequencies so that only the plane wave mode propagates, and partitions far enough apart so that higher mode interaction can be neglected, permits treatment analogous to an electric line loaded with lumped inductances, and leads to expressions for effective propagation constant and characteristic impedance. For simple case of hard walls, plots are given for attenuation, phase shift, and impedance ratio as functions of frequency, and the position and width of pass bands are noted. Measurements of attenuation in ducts with hard walls and with one absorbing wall are in satisfactory agreement with theory. In the latter case, proper choice of partitions gives a broader attenuation band (than without partitions), e.g., more than 17 db/meter over 300–1500 cps.

Paul Marcus, USA

2732. **Lawhead, R. B., and Rudnick, I., Measurements on an acoustic wave propagated along a boundary,** *J. acoust. Soc. Amer.* **23,** 5, 541–545, Sept. 1951.

Paper describes an experimental study of the sound field from a point source located at the plane boundary between two semi-infinite homogeneous and isotropic media. Work was carried out to test a more exact theory replacing inadequate plane wave reflection theory.

Two different boundaries were tested, one being formed by interface of air and sheeting of sufficiently thick Fiberglas, and the second being the effectively rigid boundary presented by plywood sheeting. Source was a probe set flush with the boundary and actuated by driving unit, power amplifier, and signal generator. Search probe was mounted from a movable boom and connected to a system of preamplifier and amplifier. Phase meter was used to determine phase of pressure at field points with respect to source as fixed reference. Impedance and propagation constant of Fiberglas were measured by use of impedance tube and phase meter.

Experimental results are presented by graphs of field-point pressure amplitude and phase vs. field-point height above boundary. Results are in excellent agreement with theory predicting rather complicated dependence of above quantities on impedances and propagation constants of media forming boundary.

Paul Tamarkin, USA

2733. **Roderick, R. L., and Truell, R., The measurement of ultrasonic attenuation in solids by the pulse technique and some results in steel,** *J. appl. Phys.* **23,** 2, 267–279, Feb. 1952.

In order to correlate the grain size and the anisotropy of their arrangement with the attenuation of ultrasonic waves transmitted through a solid specimen, authors study the sources of error due to beam spreading, geometrical boundaries, and the method of coupling used. By keeping the dimensions large, the frequency high, and by using a water buffer between the transducer and the specimen, all these errors can be made small.

Attenuation measurements have been made in the 5 to 50 megacycle range on chrome-molybdenum-steel specimens, and these have shown large differences in ultrasonic attenuation for samples of the same chemical composition but different heat treatment. The differences are connected with the anisotropy which appears in the photomicrographs. The application of the methods to metallurgical problems and the physics of solids is suggested.

Warren P. Mason, USA

2734. **Andreae, J. H., and Lamb, J., Ultrasonic relaxation processes in pure liquids,** *Proc. phys. Soc. Lond.* (*B*) **64,** part 12, 384B, 1021–1031, Dec. 1951.

Analysis of ultrasonic absorption with consideration of relaxation of energy transfer. Two cases are considered: (a) Molecules exist in two states differing in energy; (b) molecules may be unassociated or associate to double molecules. Relationship to analyses by Hall and Herzfeld is stated.

To use formulas to interpret experimental data, compute, for various assumptions, the relaxing component of specific heat and make log-log plot versus temperature. Make these graphs coincide with corresponding theoretical curves of shifts parallel to coordinate axes. Amounts of shifts show which assumptions hold; the shifts for the acceptable graph give quantitative information. Authors make application to acetic and propionic acids, carbon disulphide, and toluene.

Eric W. Beth, USA

Ballistics, Detonics (Explosions)

(See also Revs. 2545, 2713)

2735. Brändli, H., Barrage firing with small caliber weapons in antiaircraft defense (in German), *Flugwehr und Technik* **13**, 6, 7, 8: 129–140, 160–173, 189–193; June, July, Aug. 1951.

Author has investigated the current problem in Switzerland, when considering the question of providing the antiaircraft artillery with new weapons. Small-caliber weapons are, of course, especially important in an alpine country where attacking aircraft are to be expected suddenly and surprisingly at low altitudes and short ranges (<1500 m). Such targets should be combatted by small-caliber guns (about 20 mm) which can be aimed very rapidly. The fire from these weapons is a sort of "barrage"; short bursts of fire against a barrage point in the course of the target, arranged in such a way that the fire is most dense during the short period when the target passes through the barrage.

After a thorough scientific and theoretical investigation of all pertaining factors, author gives some practical conclusions concerning the general requirements of the designs.

The result of this fire depends first of all on the density of fire—referring to time and space—and, further, to the rate of fire, the time of flight, the sights, and the method of firing.

The effect of one single-barreled weapon increases rapidly with the rate of fire, up to a limit value (about 1000 rounds per min), above which the increase is slower. An antiaircraft gun of 20 mm thus ought to fire at least 1000 rounds/min. Concentrated fire from several single-barreled weapons against the same target is, in principle, better than divided fire against several targets. The lower the rate of fire, the more weapons are to be set in. Even at 1000 rounds/min, several guns have to fire at the same time against the same barrage point, especially when the target is a rocket or other target with a speed of 400–500 m/sec or more.

As to multi-barreled weapons (double, triple, quadruple), author emphasizes the importance of a regular sequence (non-simultaneous firing of two or more barrels), especially at a lower individual rate of fire than 1000 rounds/min. Such double, triple, and quadruple guns with all barrels firing simultaneously give a lower effect than two, three, or four single-barreled weapons with the same individual rate of fire. By regular sequence (the barrels firing in series one after another), again the multi-barreled weapon gives a better effect.

The velocity of the projectile is of course very important. There is no limit to the demand for the shortest possible time of flight. The sights should be simple to operate and should fulfil the following conditions: (1) Rapid finding of the course of the target; (2) good fire control, giving small differences in time and space (great density of fire referring to time and space); (3) good technical and tactical mobility (as many barrages as possible against the same target). Ring sights cannot fulfill these three conditions.

Author emphasizes the need of spare barrels at this high rate of fire.

The author's theoretical investigation of this subject is worth a thorough study.

R. Sjöberg, Sweden

2736. Swett, C. S., Jr., Effect of gas stream parameters on the energy and power dissipated in a spark and on ignition, Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 353–361, 1949. $13.50.

The following results were obtained on ignition of a flowing combustible gas at low pressure: Energy requirements as a function of fuel-air ratio showed that the minimum energy occurred at a fuel-air ratio of approximately 0.075 to 0.095. The energy required for ignition increased almost linearly with velocity in going from 5 to 54 fps. At a pressure of 4 inches of mercury absolute, the energy required for ignition at a velocity of 54 fps was approximately four times that required at 5 fps. At a pressure of 2 inches of mercury, slightly less than twice the energy was required over the same velocity range. The effect of time of discharge on energy required for ignition showed that the minimum energy occurred at a discharge time of less than 300 microseconds.

From author's summary

2737. Bowden, F. P., and Yoffe, A., Hot spots and the initiation of explosion, Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 551–560, 1949. $13.50.

See AMR **3**, Rev. 2804.

2738. Kistiakowsky, G. B., Initiation of detonation of explosives, Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 560–565, 1949. $13.50.

Nonmathematical review of theoretical and experimental work during and since World War II on initiation of solid explosives and relation to deflagration. Author explains "critical mass" for transition to detonation, effects of "dead-pressing," confinement, geometry, mechanical mixture of explosives, and their chemical constitution. He discusses impact sensitivity. He also correlates knowledge on all scales in laboratory and industry.

J. Corner, England

Soil Mechanics, Seepage

(See also Rev. 2541)

2739. Rodin, I. V., On the determination of mountain mass pressure taking account of surface loads (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **81**, 6, 1011–1014, Dec. 1951.

This continues the papers reviewed in AMR **5**, Revs. 283, 548. The procedures developed in these papers are extended to the analysis of the effect of surface loading on stresses within a mountain mass and on pressures exerted on the shoring of underground excavations. The conclusion is reached that one should differentiate between two types of surface loading: First, surface loads applied before tunneling through the mountain mass and, second, surface loads applied after such tunneling.

Static surface loads of the second type induce larger pressures on the shoring of underground excavations than otherwise identical loads of the first type. The removal of surface loads of the second type fully restores the state of stress which existed in the mountain mass and in the shoring of excavations prior to the application of the surface loading; the removal of surface loads of the first type does this only partially.

G. P. Tschebotarioff, USA

2740. Ohde, J., On the theory of earth pressure (in German), *Bautechnik* **29**, 2, 31–35, Feb. 1952.

This section on influence of wall movement on shape of failure surface in soil and distribution of earth pressure, continues author's series of articles [see AMR **5**, Rev. 1571]. Results of some model tests on retaining and sheet pile walls with various rotational restraints are outlined to illustrate interrelation between wall and soil movements and pressure distribution. In applying findings to foundation behavior, author suggests that central shear zone below rough foundations is bound by curved surfaces. Latter shape is not compatible with boundary conditions, which require plane surfaces as shown theoretically by reviewer [see AMR **5**, Rev. 2202] and supported by observed

ground movements below model footings [AMR 3, Rev. 1182].
G. G. Meyerhof, England

2741. **Tager, A., New methods of soil stabilization** (in French), *Ann. Inst. tech. Bât. Trav. publics* **5**, no. 51, 281–308, Mar. 1952.

The use of (1) ordinary lime and (2) the resin, aniline furfural, both of which have been experimented with in the United States, were used on a silt soil to evaluate their relative stabilizing properties. The principal influence of the lime treatment was to reduce the plasticity index and the detrimental effects of saturation on the mechanical properties. Aniline furfural showed a strong waterproofing property, also reduced the compressibility twice as much as the lime treatment. The equations of Westergaard, Burmister, and Southwell are compared for computing stresses under tracks and landing-strip rigid pavements.

Eben Vey, USA

2742. **de Vries, D. E., A nonstationary method for determining thermal conductivity of soil in situ,** *Soil Science* **73**, 2, 83–89, Feb. 1952.

Paper describes a measuring instrument for determining thermal conductivity of soils in situ, and presents some results obtained in the field. Device is based on theory of nonsteady flow of heat from a long cylindrical surface source of small radius. In principle, method seems to originate from Stålhane and Pyk's investigations on specimens of porous material [*Tekn. Tidskr.*, 1931], and later studies of the thermal conductivity of liquids by Van der Held and Van Drunen [*Physica*, 1949].

P. Wilh. Werner, Sweden

Geophysics, Meteorology, Oceanography

(See also Revs. 2537, 2565, 2687)

2743. **Lingelbach, E., Advection and air pressure tendency** (in German), *Meteor. Rdsch.* **4**, 11/12, 209–210, Nov./Dec. 1951.

2744. **James, R. W., The structure of mean circulations,** *Tellus* **3**, 4, 258–267, Nov. 1951.

A discussion of how to represent parametrically the features of westerly flow across a given longitude results in the definition of a dozen new terms. The study is mainly centered on 80°W where a certain amount of steadiness can be detected in the mean geostrophic westerly flow, and the main justification rests on the usefulness of the zonal index and associated concepts. After expressing surprise that no investigation of mean westerly flow had yet been made along the Greenwich meridian, author provides the answer by his own study, in which he finds such great variability that mean westerly flow has no significance, a fact of which European meteorologists have long been well aware. More interesting is the inconclusive discussion of why flow should be so much more variable at 0° than at 80°W. Other latitudes are mentioned, but observations, particularly in the southern hemisphere, are inadequate for the author's purpose.

It is desirable that meteorologists should be conscious of the observational facts, but here we find no new data. If we are to have a parametric representation of some feature, a theoretical discussion of why certain parameters can be expected to be meaningful is required; but here we have only an attempt to find a simple way of talking about curves derived from observations. Author also refers to his own unpublished work and makes frequent use of the phrase "it can be shown that . . . "—all of which does not help to convince.

R. S. Scorer, England

2745. **Taylor, R. J., The dissipation of kinetic energy in the lowest layers of the atmosphere,** *Quart. J. roy. Meteor. Soc.* **78**, 336, 179–185, Apr. 1952.

The supply of kinetic energy to a shallow layer of air is considered. The cases chosen for analysis comprise occasions of comparatively strong wind and of fairly small temperature gradient so that the supply of kinetic energy from the vertical flux of total heat is not important at small heights. In these cases the diffusive flux of kinetic energy is also shown to be negligible. Hence it follows that, on these occasions, the rate of dissipation per unit volume is given by the product of the local values of the shearing stress and vertical gradient of mean velocity when steadiness and horizontal uniformity of the turbulence are assumed. Estimates of the rate of dissipation per unit mass at heights from 1 m to 50 m are made for particular occasions and used, together with the observed energy densities, to provide estimates of the size of the dissipating eddies at the heights of observation, according to expressions given by L. F. Richardson and G. I. Taylor.

From author's summary by Neal Tetervin, USA

2746. **Kampé de Feriet, J., Atmospheric turbulence** (**Lecture series no. 7, prepared by S. I. Pai**), Univ. Maryland, Inst. Fluid Dynamics appl. Math., 40 pp., 1950. $.65.

2747. **Jacchia, L. G., and Kopal, Z., Atmospheric oscillations and the temperature profile of the upper atmosphere,** *J. Meteor.* **9**, 1, 13–23, Feb. 1952.

A summary is given of the linearized dynamical theory of atmospheric tides, and calculations of resonant periods are made for a number of atmospheres with different temperature profiles. A profile is established which is consistent with the experimental information relating to the temperature of the atmosphere within the limits of experimental uncertainty and which, according to the authors' calculations, has the correct oscillatory properties.

M. V. Wilkes, England

2748. **Kanai, K., Relation between the nature of surface layer and the amplitudes of earthquake motions,** *Bull. Earthq. Res. Inst. Tokyo Univ.* **30**, part 1, 31–37, Mar. 1952.

Author extends previous investigation [AMR 4, Rev. 3738] of effect of solid viscosity in a surface layer on amplitudes of ground motion. A table is derived which, in conjunction with data from seismic prospecting, author considers will be of value in connection with building problems in earthquake areas. Some theoretical consideration is given to the case of a doubly stratified surface layer.

K. E. Bullen, Australia

2749. **Blanchard, D. C., The behavior of water drops at terminal velocity in air,** *Trans. Amer. geophys. Un.* **31**, 6, 836–842, Dec. 1950.

Stroboscopic pictures were taken of drops rising slowly in a vertical airstream. Large drops (spherical diameter > 5 mm) show natural oscillations in horizontal plane. Turbulence is effective in breaking up large drops, but both natural oscillations and effect of turbulence are greatly reduced by introducing air bubble within drop. Author concludes that breakup is due to oscillations. Growth of large drops by coalescence is studied; smaller drops were frequently observed to "bounce off" larger drops. Reviewer believes this is a valuable contribution to observational literature. No theoretical discussion of results is given.

George S. Benton, USA

2750. **Best, A. G., The evaporation of raindrops,** *Quart. J roy. Meteor. Soc.* **78**, 336, 200–225 Apr 1952.

The evaporation of a single drop of water as it falls through an atmosphere in which the lapse rate is 6.5 C/km and the surface temperature either 15 C or 41 C is examined. By making certain justified assumptions, it is shown that the change in surface area of a large drop (i.e., with radius exceeding 0.15 mm) as it falls from height z_1 to z_2 is proportional to $(l - f)^{1.13} \exp(-lz)$, where $100 f$ is the relative humidity and l is a constant. Values are given for the constant of proportionality and for l. If the drop has a radius less than 0.15 mm, the change in volume of the drop is proportional to $(l - f)^{1.068} \exp(-lz)$.

These results are then used to assess the effect of evaporation on the size and size distribution of raindrops falling through a constant atmosphere. It is shown that if the size distribution of raindrops at some initial height is given by $l - F = \exp[-(2a/b)^n]$, where F is the fraction of liquid water comprised by drops with radius less than a, and b and n are constants, then evaporation will lead to a change in the values of b and n but will not affect the general validity of the formula. As the rain falls through the nonsaturated air, the distributive index n tends to a value between 3.5 and 4.0 whether it was greater or less than such a value initially. If the initial value of n is less than 3.0, the scale diameter b increases as a result of evaporation. If the initial value of n exceeds about 3.4, the scale diameter decreases. The effect of evaporation upon the radar response from falling rain is also examined.

In the last part of the paper the effect of the evaporation of rain into air which is initially unsaturated is considered. It is shown that the air temperature tends to a steady value and the relative humidity to 100 per cent.

From author's summary by Phillip Eisenberg, USA

2751. Syōno, S., Ogura, Y., Gambo, K., and Kasahara, A., On the negative vorticity in a typhoon, *J. meteor. Soc. Japan* **29,** 12, 397–415, Dec. 1951.

Calculations of vorticity from observational data of two typhoons are presented showing zones of strong negative vorticity at different levels round the central zone of positive vorticity. This was postulated in Syōno's theory [*Geophys. Notes, Tokyo Univ.*, 1(7), 1948]. The significance of these zones in the light of existing theories and their connection with the meteorological elements are discussed fully. H. Merbt, Sweden

2752. Zubyan, Zh. D., Formation and development of cyclones and anticyclones [Vozniknoveniye i razvitiye tsiklonov i antitsiklonov], Leningrad, Gidrometeoizdat, 1949, 52 pp.

An "advective-dynamical" theory of the meteorological processes, developed by Russian meteorologists N. L. Taborovsky and Kh. P. Pogosyan in 1947, is opposed to the theory of frontiers by V. Bjerknes. Author's theory is based on the distribution of the air pressure and temperature in the middle troposphere. Advective variations of the air pressure and temperature are explained as the result of the horizontal transport of the air masses. Dynamical variations are due to unsteady movement and deviation of winds. For the practical application, a map of the absolute isobaric surface of 700 millibars is superposed over the map with the relative topography of the 500-mb surface above the 1000-mb surface.

The booklet is a manual for the practical synoptists; it contains several examples of the forecasting of the movement of cyclones and anticyclones. Steponas Kolupaila, USA

Lubrication; Bearings; Wear

(See also Revs. 2628, 2629, 2646)

2753. Lane, T. B., and Hughes, J. R., A practical application of the flash-temperature hypothesis to gear lubrication, 3rd World Petr. Congr., The Hague, 1951. Proc., sect. 7, 320–327.

The postulate of Blok, that seizure will occur in gears when the temperature in the contact reaches a value characteristic of the combination of sliding system and lubricant, is investigated to explain the behavior of oils in a gear rig at different speeds. An empirical formula is given confirming Blok's hypothesis, but this formula is only applicable to the special experimental arrangement used for the investigations. Georg Vogelpohl, Germany

Marine Engineering Problems

2754. Weinblum, G. P., Progress in the computation of wave resistance of ships, "Hydrodynamics in modern Technol.," Hydrody. Lab., Mass. Inst. Technol., 86–100, 1951.

Paper reviews in concise detail the mathematical developments leading to present theoretical knowledge of wave resistance. Since the time of Kelvin, many extensive analyses have been conducted, but in few instances have they been carried to specific numerical results. Their usefulness to date has lain rather in qualitative indication of functional trends with basic shape parameters and Froude number. Author stresses the need for further numerical evaluation, elimination of deficiencies in theory, and enlargement of analytical scope. Selected bibliography of 59 titles is appended. Hunter Rouse, USA

2755. Smith, S. L., Ship research, *Instn. mech. Engrs. Proc.* (*A*) **166,** 1, 48–63, 1952.

Lecture gives authoritative survey of present-day British research applied to shipbuilding and marine engineering, and trends of future research in these fields, comprising (1) Ship structures, (2) Ship hydromechanics, (3) Ship performance, (4) Ship machinery. Reference is made to hull-strength problems, strain measurements on full-size ships and on structural members, with short description of special testing machines and results obtained. Problems on structural materials, including light alloys, and welding problems are briefly discussed, as well as corrosion, fouling, and vibration problems. Research in the field of ship resistance and propulsion, including propeller cavitation, is presented at greater length with reference to the important full-size hull-resistance trials of the *Lucy Ashton*. The stimulation of turbulent flow with large ship models, here presented as an important recent development in experiment tank technique, has been standard practice on the European continent for many years. The following of a standard code of procedure with measured mile trials of merchant ships as formulated by B.S.R.A. is stressed. Current British research on steam and gas turbines, water-tube boilers, and Diesel engines is discussed in detail; a short survey is given on gearing, shafting, and propellers. Excellent compilation of literature references appears in appendix. Lecture gives impressive statement of applied cooperative industrial research in the United Kingdom. L. Troost, USA